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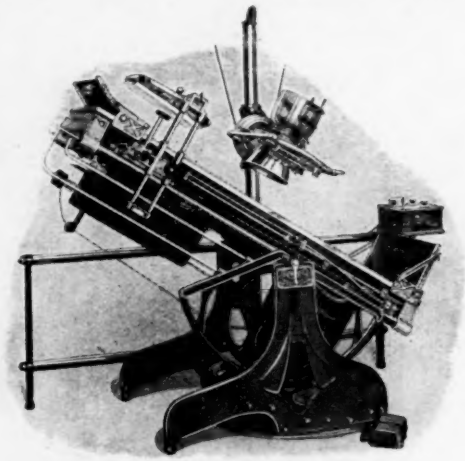

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THE AMERICAN JOURNAL OF ROENTGENOLOGY

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THE RELATION OF THE SCIENCE OF PHYSICS TO RADIATION THERAPY*

By HENRY SCHMITZ, A.M., M.D., F.A.C.S.

CHICAGO, ILLINOIS

THE honor you bestowed upon me at the last annual session of the AMERICAN RADIUM SOCIETY by election to the presidency was not expected and was reluctantly accepted. I was aware of the many duties the office would bring and my inability to do justice to its proper representation. The year was hardly on its way, when the various officers and committees began to make preparation for the 1921 session. I observed with a great deal of satisfaction that my office was hardly on its way when the various officers and members of committees had actually incurred a goodly amount of work. It is to their efforts that the sixth annual meeting has been such a great success, and that the scientific part of the program equals that of the preceding meetings. Harvard University, one of the most renowned seats of learning in the world, magnanimously responded to our request for active participation in the scientific proceedings and Dr. Robert Greenough has consented to give a clinic at the Huntington Memorial Hospital to demonstrate the rapid strides radiation therapy is making. I am certain to voice your sentiment in extending to Dr. Greenough and his coworkers, to the officers and committees, the deep-felt thanks and gratitude of our Society. Permit me, also, to take this opportunity to thank you for the honor you have conferred in electing me to the presiding office for the sixth annual session.

Radium therapy and the sister science *x*-ray therapy are entering upon a new era. Empiricism and uncertainty in the therapeutic application of radiation are being rapidly replaced by scientifically correct methods. A biological unit of dose has been defined, measuring instruments have been perfected accurately to gauge the dose, and clinical investigations have progressed so far that lethal dosages for normal and abnormal tissues have been established. Laboratory researches have been continued to investigate the influence of radiations on the blood and blood-forming organs, to interpret correctly radiation sickness or toxemia and to explain their influence on the prognosis of radiation therapy. Much of the progress would not have been made had not the sciences of chemistry and physics and medicine worked hand in hand. History repeats itself. Roentgen, the physicist, discovered the *x*-ray. Madame Curie, the chemist, extracted radium, after Henri Becquerel had detected

*Presidential Address delivered at the Sixth Annual Meeting of THE AMERICAN RADIUM SOCIETY, at Boston, June 6, 1921.

radio-activity in uranium ores. Scientists and physicians have since labored unceasingly to evolve correct methods of technique and establish laws of indications and contra-indications for the medicinal applications of radiations. The fact that a solution of the many problems of radiation therapy can be reached only by the joint labor of chemist, physicist and physician has been recognized by our Society from the beginning. We are, indeed, fortunate to count among our members the foremost chemists and physicists of our country.

During the last year I had the opportunity to observe the radiation investigations done in England, France and Central Europe. Of all the various researches carried on I deem those the most important which are concerned with the measurement of radiation. Permit me, therefore, to explain them in detail.

In 1914, B. Szilard of Paris devised an electrometer that was standardized to measure radiation units of uranium. With the instrument it was also possible to measure directly gamma radiations of radium from 1/100 milligram to 500 milligrams without time-consuming calculations. A deflection of the hand of the electrometer indicates the amount of gamma radiation of a radio-active preparation subjected to measurement. W. Friedrich of the Freiburg University perfected an instrument, which is composed of an electrometer and an ionization chamber of 1 c.c. volume. The latter is attached to the electrometer or may be attached to any electroscope by a dielectric cable of any desired length. The ionization chamber is not larger than an ordinary F.30 sound. The advantage of the modification of Szilard's electrometer consists in the possibility of inserting the measuring chamber into body cavities and water phantoms and thus measuring the radiation intensities actually obtained at the seat of the lesion.

Connecting the ionization chamber with a Wilson electroscope Friedrich was able to measure the intensities of radiations at various distances from the source. The measurements were made with a preparation of

TABLE I

Measurements of a 50 mg. Radium Element Capsule. Length 2.28 cm., Filter 1.5 mm. Brass and 5 mm. Celluloid.

a. In Water

Distance in cm.	*Measured Doses in % of Dose at 1 cm. distance*	*Doses Calculated from Absorption and Distance*	*Differences in % of the Calculated Doses*
1	100.		0.
2	23.2	22.5	3.1
3	10.4	9.0	15.6
4	5.4	4.55	18.7
5	3.3	2.62	25.9
6	2.2	1.64	34.1
8	1.2	0.72	66.6
10	0.7	0.39	79.5

b. In Air

1	100.	100.	
2	25.	25.	
3	11.2	11.1	
4	6.0	6.3	
5	4.0	4.0	
6	2.6	2.8	
8	1.4	1.5	
10	1.0	1.0	

mesothorium equalling 46.46 radium element gamma radiation and enclosed in a silver capsule of a diameter of 4.6 mm. and a length of 2.28 cm. It was placed in a brass filter of 1.5 mm. wall thickness and surrounded by a celluloid tube of 5 mm. wall thickness to arrest the Sagnac rays effectually. The measurements were taken in water and air and compared with the calculated dose. The differences in the percentages of the measured and calculated doses and those taken in water and air are due to the secondary radiations formed in water.

each of a radium element content of about 50 mg. and a length of about 3 cm., were placed in a brass filter tube of a length of 8.28 cm. and wall thickness of 1.5 cm., surrounded with a celluloid tube of a wall thickness of 5 mm. The measurements were taken at various distances in a vertical direction from the center of the longitudinal axis in water as well as in air. The results are shown in Table II.

If the source of radiation be a point or ball-like body of equal dimensions all around, then the planes of like doses, termed

TABLE II

Measurements of Three 50 mg. Radium Element Capsules. Length 2.25 cm., Filter 1.5 mm. Brass and 5 mm. Celluloid.

a. In Water

Distance in cm.	*Measured Doses in % of Dose at 1 cm. distance*	*Doses Calculated from Absorption and Distance*	*Differences in % of the Calculated Doses*
1	100.	100.	0.
2	32.4	22.5	44.0
3	15.7	9.0	74.5
4	9.3	4.55	104.5
5	5.6	2.62	113.5
6	4.2	1.64	156.0
8	2.4	0.72	233.5
10	1.5	0.39	285.0

b. In Air

1	100.		0.
2	30.5	25.0	22.0
3	15.0	11.1	34.9
4	9.3	6.3	48.8
5	6.3	4.0	57.6
6	4.6	2.8	67.0
8	2.6	1.5	66.5
10	1.6	1.0	60.0

Since the secondary radiations in water are practically of the same value as those in the human body, the deductions apply equally to both. (See Table I.)

In the treatment of diseases it is often feasible to use much larger amounts of radium. Therefore several capsules were placed in filter tubes in a so-called tandem formation. Measurements of such an arrangement showed more or less marked deviations from the values obtained from the single capsule. These mesothorium capsules,

standard or isodoses by Friedrich, surround the source of radiation concentrically. The radium tubes which we use in deep therapy are of a cylindrical shape. One might assume that the planes of isodoses would form parallel with and cylindrically around the tubes. However, if actual measurements are taken in water for both preparations, that is, the one tube and three tube arrangements, the results of the measurements as given in Tables III and IV are obtained.

Having made these determinations Fried-

TABLE III

Measurements of 50 mg. Radium Element Capsule. Length 2.28 cm.

Distance in cm.	*Doses Measured in Center Vertically to Long Axis*	*Doses Measured at End Vertically to Long Axis*	*Doses Measured in Direction of Longitudinal Axis*
1	100.0	70.	25.
2	23.2	20.	9.4
3	10.4	9.0	5.0
4	5.4	5.0	3.2
5	3.3	3.1	2.1
6	2.2	1.9	1.4
8	1.2	0.9	0.8
10	0.7	0.5	0.5

TABLE IV

Measurements of Three 50 mg. Radium Element Capsules. Length 8.25 cm.

Distance in cm.	*Doses Measured in Center Vertically to Long Axis*	*Doses Measured Vertically to Long Axis Midway Between Center and End*	*Doses Measured at End Vertically to long Axis*	*Doses Measured at End in Direction of Long Axis*
1	100.	61.5	36.4	19.5
2	32.4	22.7	14.7	7.8
3	15.7	11.7	8.9	4.5
4	9.3	7.4	5.4	2.8
5	5.6	4.9	3.9	2.2
6	4.2	3.1	3.0	1.6
8	2.4	1.8	2.0	1.0
10	1.5	1.3	1.3	0.4

rich could now proceed to ascertain the isodoses for radium preparations of the same length, i.e., 2.28 and 8.28 cm. If the radiation intensity is assumed to be 100 per cent at a distance of 1 cm. in an axis drawn vertically to the center of the longitudinal axis, then the percentages 90, 80, 70, 60, 50, 40, 30, 20, 10, 5 and 2 give the curves for isodoses, as seen in Figures 1 and 2 below.

Thus we gain from the researches of a physicist a correct idea of the actual intensities of radiations. The therapeutic application of these values has been worked out by

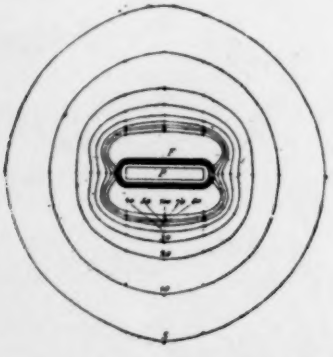

Fig. 1. Curves of Isodoses of a Radium Capsule of a length of about 3 cm. [Friedrich].

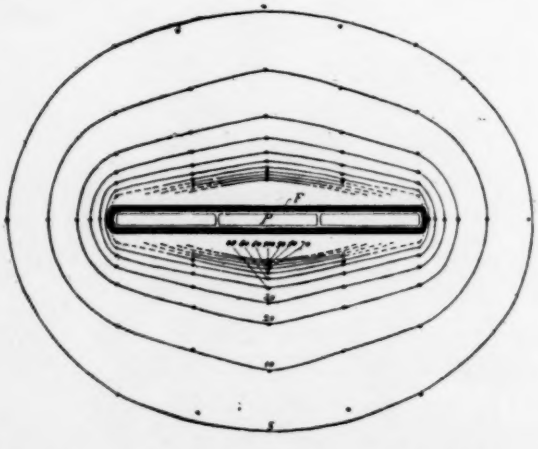

Fig. 2. Curves of Isodoses of Three Radium Capsules of a total length of about 9 cm. [Friedrich].

Opitz and Friedrich. The iontometer expresses radiation values in electrostatic units, shortly designated by a small "e." If a capsule of radium containing 30 mg. element filtered through 1.5 mm. of brass and 5 mm. of celluloid is applied to the skin at a distance of 1.5 cm. the application to produce necrosis of the skin must be extended to seventy hours, i.e., 2100 mg. e hrs. This measures 300 e. Hence 7 mg. e hrs. would equal 1 e.

If we refer to the tables and figures of isodoses, we see that, if a 50 mg. radium element capsule be used, the dosages at various distances for an hour's application are as shown in Table V.

TABLE V

Isodoses for Various Distances and Time Durations.

Distance in Cm.	*% of Isodoses*	*% of E.S.D. of 50 mg. Ra. El.*	*% of "e" Units*
1.5	40	100	14.2
2.3	20	50	7.1
3.4		25	3.55
4.7	5	12.5	1.78
5.6	2	5	0.71

	Exposure of						
Distance in Cm.	*10 Hrs.*	*20 Hrs*	*30 Hrs.*	*40 Hrs.*	*50 Hrs.*	*60 Hrs.*	*70 Hrs.*
1.5	71.0	142.0	213.0	284.0	355.0	426.0	497.0
2.3	35.5	17.0	106.5	71.0	177.5	213.0	248.5
3.4	17.75	35.5	53.25	142.0	88.75	116.5	114.25
4.7	8.9	17.8	26.7	35.6	44.50	53.4	62.30
5.6	3.55	7.1	10.65	14.2	17.75	21.3	24.85

Let us apply these observations to a practical example, for instance a cervical cancer.

The limits of the diseased area in cases that can be considered to be benefited by radiations are identical with the lateral bony pelvic walls, the pelvic inlet above, the pelvic outlet below. The axis of the cervix lies in the axis of the true pelvis. The uterus, adnexa and regional lymph glands are contained within the true pelvic cavity. The antero-posterior and transverse diameters measure 12 and 13 cm. respectively. A radium capsule of 50 mg. element will therefore give isodoses as indicated above and we at once know the exact intensities that may be obtained in any part of the true pelvis.

The question arises, How may we apply these results in therapy? Obviously a biologic unit of dose must first be ascertained that may be exactly reproduced by any one using radiations; secondly, comparative doses of normal and abnormal tissues must be determined and expressed in a known quantity.

The normal skin reacts to a dose of 160 to 170 e, with a mild inflammatory change characterized by the appearance within eight to ten days following radiation of an erythema and subsequent desquamation, and after three to four weeks by epilation and brownish discoloration of the skin area. This reaction has been termed an erythema dose (abbreviated E.S.D.). It is the standard of comparison for all other tissues and radiation reactions. A destructive reaction seen as blistering and subsequent necrosis of the skin is obtained with a radiation dose of 300 e, and is known as the death skin dose. It is, therefore, produced by about twice a dose of the E.S.D.

A radiation of the ovaries to produce amenorrhea is produced by 33 e; a cancer

dose to cause visible and palpable resorption of the tumor and local healing within six to eight weeks by 150 e. The erythema dose for the rectal mucosa appears to be 200 e, for the mucosa of the urinary bladder about 200 e. The sarcoma dose is 120 e, the muscle tissue dose 300 e, and the tuberculosis dose 100 e (Seitz and Wintz, Opitz and Friedrich).

The object of the radiation of uterine cancer is to cause degeneration or death of all carcinoma cells contained within the true bony pelvis without causing irreparable injury of the vital structures and organs within this area. If we refer to Figure 3 we see that the rectal mucosa receives an isodose of 10 per cent, while the bladder mucosa lies within the isodose of 20 per cent. Hence we must not extend the application of 50 mg. of radium element to more than fifty consecutive hours, otherwise the bladder will be severely damaged. The dose obtained at the bony pelvic periphery is, however, so minimal (17.75 e) that instead of arresting the growth of the cancer in this location, the rays will stimulate the cancer. The conclusion must be drawn that we can never apply a sufficiently large dose of radiation that will be lethal beyond a distance of 3 cm. if we wish to avoid irreparable injury to rectum or bladder.

Various procedures have been advised to overcome this deficiency, such as longer continued intra-uterine radiations irrespective of any detrimental consequences to rectum and bladder, the insertion of needles or trochars containing radium into the parametria, the application of radium packs containing up to one gram of radium element over the suprapubic regions, and the roentgen ray. It is obvious that the solution of the problem must be one that may be used in every hamlet of our country. We must strive to enable as many cancer patients as possible to obtain the benefits of radium treatment. Roentgen laboratories are connected with almost all hospitals. Fifty or one hundred milligrams radium element could easily be obtained by a group of interested medical men.

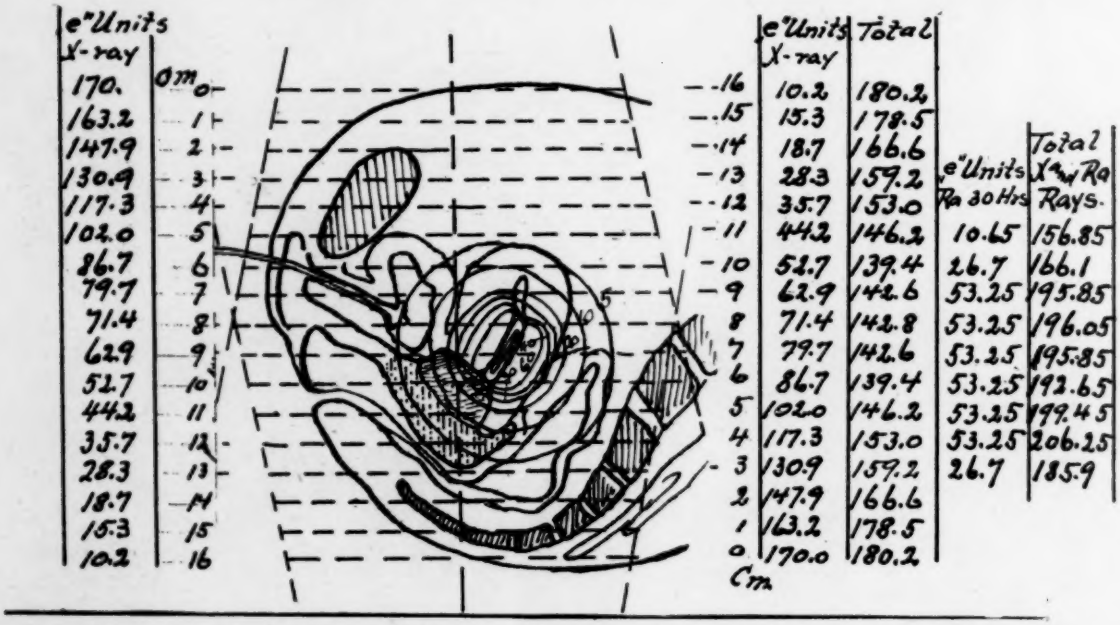

Fig. 3. Median Longitudinal Section of Pelvis showing the Intensities of *X*-rays for each Centimeter and the Isodoses of the Radium Capsule Inserted into the Uterine Canal. [After Opitz and Friedrich.]

May a combination of radium and roentgen ray therapy improve the outlook for the the patient? Again the physicists are showing us how to proceed. Coolidge and his associates, the large European clinics, with the

cooperation of physicists such as Friedrich at Freiburg, Wintz and Voltz at Erlangen, Item at Berne, have measured the absorption curves for the different qualities of *x*-rays.

Through the kindness of Dr. Coolidge and the Victor X-Ray Corporation I have been supplied with a measuring instrument. By means of it I have made actual measurements in the living subject. The values obtained are shown in Figure 3. The clinical application of the *x*-ray is performed as follows:

An exact median longitudinal section is made measuring the distance from the anterior body surface to the posterior surface and from the anterior surface to the cervix and from the posterior surface to the cervix, as seen in Figure 3. Lines 1 centimeter distant are drawn across. The *x*-ray intensities are entered for each centimeter, to the left those obtained through the anterior portal of entrance, to the right those through the posterior portal of entrance. A summation of both is entered in the second column to the right. It will thus be seen that the radiation intensities between the fourth and twelfth centimeters lack intensity values of 20 to 30 e, 170 e being the required and permissible intensity. A thirty hours' application of fifty milligrams radium element will increase the deficient intensities as follows:

At 5 cm. 146.2 + 10.65 = 156.85
At 6 cm. 139.4 + 26.7 = 166.1
At 7 cm. 142.8 + 53.25 = 195.85
At 8 cm. 142.8 + 142.0 = 284.8
At 9 cm. 142.8 + 284.0 = 426.8
At 10 cm. 139.4 + 142.25 = 285.65
At 11 cm. 146.2 + 106.5 = 252.2
At 12 cm. 153.0 + 53.25 = 206.25
At 13 cm. 159.2 + 10.65 = 169.85

At the anterior rectal wall the intensity is 146.2 + 53.25 = 199.45, at the fundus of the urinary bladder 142.8 + 53.25 = 196.05. It is seen, therefore, that the lethal dose has not been exceeded at these organs except within the limits of the uterus. This organ will become destroyed.

The exhaustive researches on radiation intensities carried on by the physicists have enabled the clinician to work out a technique that conforms to the most important requirement of cancer therapy, namely, the carcinoma must be traversed by a homogeneous radiation intensity that can cause all the cancer elements to degenerate without doing irreparable damage to the vital structures contained within this area. The future will tell us whether by this technique the prognosis of the cancer disease will be improved. The primary results obtained are better than those from the sole use of radium.

The object of the presentation of these investigations is to induce the members of the Society to carry on researches along the same line. Without the collaboration of the physicist it will be almost impossible. The empirical methods of stating radium dosage in milligram element hours and *x*-ray dosage in milliampere minutes, the practice of calculating the dose from the laws of absorption and distance without considering secondary radiations, are obsolete and unscientific. Whether the biological reaction of the secondary radiation equals that of the primary *x*-ray and gamma ray radiation is also a disputed question.

In perfecting the technique of radiation therapy we must not overlook other equally important questions that await classification and solution, such, for example, as further histological evidence of the changes in radiated tissues, which will solve the much-debated question of the supposed differences in sensitiveness to radiations of cancers of different cell structures; the reaction of the blood and blood-forming organs and the metabolic disturbances in radiated patients. Finally the study of the nature of the toxemia or radiation sickness must be investigated to establish its value either as a contributive curative or as a detrimental factor to the patient's chances of recovery. The problems are many. Yet the evident desire for investigation shown by all the members of this Society will lead to an early solution of these interesting problems.

X-RAY TREATMENT OF HYPERTROPHY OF THE PROSTATE*

By SAMUEL STERN, M.D.

Radiotherapist to Mount Sinai Hospital, and Chief of the Radiotherapy Department of the Mount Sinai Dispensary

NEW YORK CITY

X-RAY therapy of hypertrophy of the prostate gland has been carried out for a number of years. The reports that have appeared in medical literature from time to time, so far as the results are concerned, have not been very enthusiastic. They all agreed that it had a beneficial influence upon the prostatic bleeding and pain, and upon the frequency of micturition, but they thought that it had very little if any influence upon the size of the prostate and upon the amount of residual urine. They considered the treatment as chiefly indicated in the early cases, during the waiting period, and that all it may accomplish is to make these patients a little more comfortable until they reach the stage where operation would become imperative.

I think this is entirely too pessimistic a view of the situation. At least I feel that the results accomplished in a number of cases which have been under observation for five or more years justify the belief that in many instances we can do better than merely expect a temporary relief from the more distressing symptoms.

For instance: One of my patients, a man sixty-six years old at the time he was referred to me, six years ago, was advised to have an immediate operation. He had a fairly large sized prostate which gave considerable annoyance in the form of pain and very frequent micturation. Under *x*-ray treatment these symptoms disappeared promptly and have not returned up to date. He is now seventy-two years old and, so far as symptoms are concerned he is not aware of the fact that he has a prostate. Examination shows the prostate to be still enlarged, but it feels softer and is much less sensitive. In the case of a physician who was referred to me five and a half years ago at the age of sixty-four with a large prostate and the accompanying pressure symptoms, with occasional difficulty in starting micturition, the results have been equally good. He assures me that he has not the slightest trouble and that his nights are practically undisturbed. In another case referred to me five years ago at the age of sixty-seven, the patient was on the waiting list for admission to the hospital to be operated upon. His general condition was rather poor, and the surgeon was reluctant to operate, but thought it the only chance of relief. This patient had some prostatic bleeding and a great deal of discomfort and pain. These symptoms yielded promptly and the patient has not the slightest prostatic annoyance to-day.

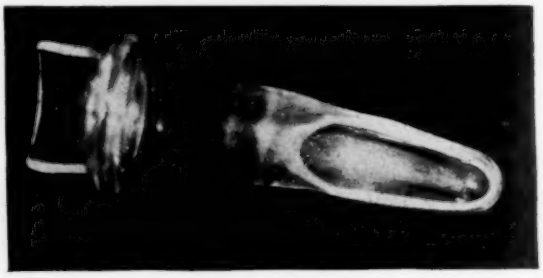

FIG. 1. Lead glass speculum with opening to fit over prostate.

Whether there is a real diminution of the size of the prostatic gland of these patients, or whether there is merely a subsidence of the chronic inflammatory condition accompanying the hypertrophy, is very difficult to determine.

In most cases there is a softening, diminished sensitiveness, and a diminution of the size of the prostate palpable, but all this may be readily explained by the subsidence of the inflammation. After all, probably with advancing years a certain amount of hypertrophy of the prostate is physiological and it is perhaps the accompanying chronic inflammatory condition that is responsible for most of the symptoms. Consequently if we

* Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., January 28, 29, 1921.

can through *x*-ray treatment influence this condition, we are in a position to do a great deal for these patients.

Knowing the effect of the rays upon glandular tissue, it is difficult to see why there should not be an actual diminution of the gland itself, and I feel quite sure that there must be. We know with certainty that in myoma, which is practically the same type of tissue as that found in these adenomas, there is a diminution, even to the extent of disappearance at times. At any rate, I have found that the majority of cases in which *x*-ray treatment was begun before the condition was too far advanced have progressed well and have escaped operation.

FIG. 2. Inclined tube-stand with lead glass attachment into which end of speculum fits.

Choice of Cases.—The most favorable cases for *x*-ray treatment are the early ones, those that come to the physician complaining of occasional pain and discomfort in the prostatic region, with frequent micturition, possibly with slowness in beginning micturition or prostatic bleeding. Cases that are far advanced—those that have already entered the catheter life—have not done well. We may improve their subjective symptoms but I have not been able to get them to resume voluntary micturition. After they reach the stage of regular periodical catheterization they have learned to depend on this entirely, and either through a mental hazard or on account of paralysis of the bladder muscle they do not seem to be able to resume their normal function even if the prostate becomes softer and the inflammatory condition is relieved. Cases that are complicated with cystitis are not improved until that condition is treated in the usual way.

Technique.—This is very important. The results depend entirely upon the proper application of the rays. The method I have used in treating my cases is as follows:

As port of entry, I use the rectum, with direct application upon the prostate and the

perineum. The patients are put in the knee-chest position. A blind pouched lead glass tube (Fig. 1), with an opening to fit over the prostate, is inserted into the rectum. The tube is covered with a thin rubber finger cot to prevent the edges from injuring the mucous membrane.

The tube-stand, with the proper filters in position and a small lead glass tube attached (Fig. 2), is now approximated to the lead glass speculum so as to make a continuous channel (Fig. 3).

The stand is tilted so that the rays will strike the prostate at a direct angle. Care is

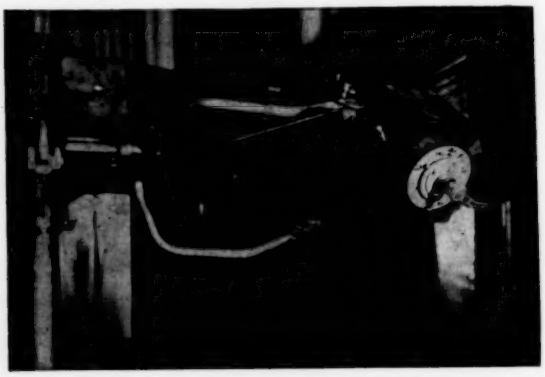

FIG. 3. Inclined tube-stand with lead glass speculum approximated.

taken that as the speculum is inserted at each treatment the oval opening is applied over a different lobe of the prostate.

In treating through the perineum, the small lead glass tube on the stand is put in direct contact with the perineum.

Dosage.—These patients are treated in series. Four weekly applications to the prostate and perineum are considered as one series. This is followed by an interval of one month, when the second series is given.

If there is a marked improvement at the end of the second series, the interval of rest is prolonged to two months before the third series is given. If not, it is given at the end of one month.

After three series have been given the interval of rest between applications should be at least two months. The number of series will depend upon the results accomplished. As a rule, there should be a decided improvement at the end of three series. If there is no change in the patient's condition at the end of this time, it is probably useless to continue with further treatments.

After the symptoms have subsided and the patients have been made thoroughly comfortable, the treatments are discontinued, but as a prophylactic measure I have found a great deal of benefit in giving these patients one series of treatments at intervals of six months over an indefinite period. This is undoubtedly worth while, and if your patients belong to the intelligent classes they will gladly submit to it. They have such a wholesome fear of the recurrence of their discomfort and of the possibility of an operation becoming necessary, that they will rather look forward to the treatments.

The amounts of ray given in my cases were as follows:

Time	*Distance*	*Spark gap*	*Ma.*	*Filter*
5 m.	Perineum, 7½ in. Prostate, 9½ in.	9 in.	5-6	4 mm. Aluminum

The difference in the distance used between the perineal and prostate applications is due to the difference in the length of the lead glass speculum used.

This dosage, applied in a series as above described, should not produce an erythema at any time during the course of the treatments—at least it has not done so in any of the cases I have treated.

SUMMARY

1. *X*-ray treatment of hypertrophy of the prostate is of decided value, and should be given a trial in all the early cases.

2. Many of the cases so treated will not only be temporarily benefited but may escape operation altogether.

3. Cases far advanced, those that have reached catheter life, will be only temporarily and subjectively benefited by the treatment.

4. Prophylactic *x*-ray treatments, to safeguard against recurrence of symptoms in improved cases, are undoubtedly of value and should be carried out in every case.

ROENTGEN RAY CARDIAC STUDIES

By CHARLES L. MARTIN, E.E., M.D.

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THE literature of the past twenty years has contained many excellent contributions covering both the normal and the abnormal roentgen ray appearances of the heart. Dr. Williams[1] of Boston published an article on this subject in 1899, and much was written in German during the early years of the twentieth century. However, the American literature has been devoted more to the discussion of technique and to the study of the normal heart, and it is for this reason that the author is presenting a series of tracings from teleroentgenograms of the chests of patients suffering from actual cardiac conditions. This brief article can in no way compare with the excellent works of such eminent men as Groedel[2] and Vaquez and Bordet[3], but it will perhaps emphasize the practical value of the roentgenogram in the field of cardiology.

TECHNIQUE

Arguments for and against the various techniques tend to carry one far afield, and it has been thought best merely to describe the methods used in studying the cases which are to be presented. These methods are fairly simple and can be executed in a reasonbly short time. They constitute the routine cardiac examination which has been used by the Roentgen Ray Department of the Massachusetts General Hospital for many years and which is fully described by Holmes and Ruggles[4].

The patient first stands facing the observer, with his chest against a fluoroscopic screen of sufficient size to make possible the visualization of all of both lung fields. Tracings are made of the cardiac outlines and the upper and lower limits of excursion of the diaphragm during normal respiration, care being taken to indicate the point of junction of the left auricle with the left ventricle. The patient is then asked to hold his breath in both forced inspiration and forced expiration, while tracings are made of the positions of the domes of the diaphragm and of the left border of the heart. The patient's left hand is next placed upon the top of his head and he is turned to his left until the shadow of the great vessels assumes its narrowest transverse diameter. At this point a tracing of the outline of the great vessels is made and the lower posterior mediastinal space is carefully studied in full inspiration to determine whether or not it is obliterated by the shadows of enlarged auricles or a pericardial effusion. Abnormalities in pulsation are noted on a sheet provided for the purpose. The examination is completed by taking a teleroentgenogram with the anterior portion of the patient's chest held squarely against a cassette. The target of the tube is placed at a distance of seven feet from the cassette and centered on a level with an imaginary line drawn through the scapulae some 2 inches above the lower tips of the angles.

After the roentgenogram is developed, it is marked off with a soft lead pencil as shown in Figure 1, which represents the anatomical divisions of the cardiac shadow. If the shadows of the inner ends of clavicles exactly span the shadows of the bodies of the upper thoracic vertebrae, the plate has been correctly made and is suitable for mensuration. Otherwise it should be discarded, because a slight amount of rotation causes a considerable error in the measurements. The center line is drawn through the center of the shadows of the spinus processes of the vertebrae. "MR" and "ML" represent the distances to the right border and to the left border ordinarily percussed out by the internist. The line "L" is drawn from the point of junction of the right auricle with the right border of the ascending aorta to the apex. Quite often the apex cannot be made out in the roentgenogram. This is par-

ticularly true where the diaphragm is high, as in obesity. In such cases it is necessary to continue the curve of the left ventricle downward and to the approximate position of the apex. "X" is drawn perpendicular to the line "L" from the point of junction of the right auricle and right diaphragm. This point is often not sharply defined, but a slight error in locating it will make very little difference in the length of "X". "Y" is drawn perpendicular to the line "L" from a point on the border of the left auricle appendage. The limits of this appendage cannot be made out on the average roentgenogram of the normal heart, but the length of "Y" will not vary appreciably if the point be selected anywhere along the approximated border of this structure. It is evident that "X" plus "Y" or "B" is the dimension which is increased with enlargement of the auricles, while "L" is more likely to be increased with ventricular enlargement. The dimension marked "Gt. Vs." extends from the right border of the ascending aorta to the left border of the descending aorta, and represents the width of the aortic arch. In some cases the left border of the descending aorta is obliterated by the shadow of the pulmonary artery or left auricular appendage and in such cases the dimension "Gt. Vs." represents the width of the great vessels. It must be remembered that the right border of the shadow of the great vessels is in reality the right border of the ascending aorta, since the superior vena cava casts little or no shadow. In addition to these measurements, it is wise to lay off the internal transverse diameter of the chest.

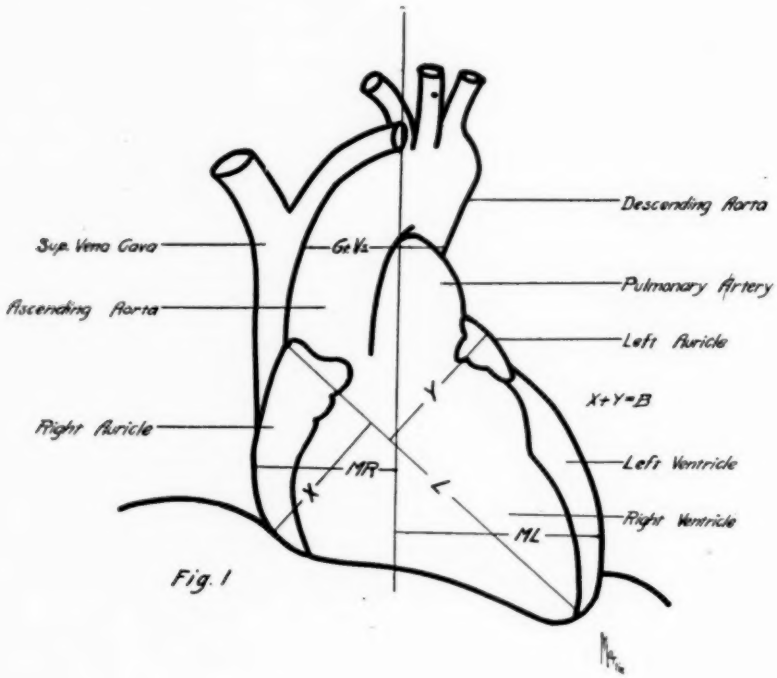


Fig. 1

VALUE OF THE EXAMINATION

From the examination as outlined above, it is possible to determine the size and shape of the heart and also to determine whether it moves with respiration. The study of pulsations is often disappointing because the excursion of the cardiac borders is so slight that variations are made out with difficulty. According to Groedel, the excursion of the left border of the left ventricle with each heart-beat rarely exceeds two millimeters.

The size and shape of the structure are the most important factors and they can both be determined from the seven-foot plate,

although the fluoroscope brings out variations in shape much better because of distortion. Many good cardiologists now admit that percussion of cardiac outlines is often not a reliable procedure. Danzer[5] has recently called attention to the fact that Thomas Lewis is now using the apex beat in approximating the size of the heart. The same author points out the possible sources of error in such a method and insists on the use of the roentgen ray. Dr. George C. Shattuck[6] demonstrated the inaccuracy of percussion in cardiac work at the Massachusetts General Hospital in 1916, and published an excellent article on the subject at that time. It is now rather generally conceded that the dimensions obtained from the roentgenogram are accurate, but the chief difficulty arises in determining whether the individual heart in question is too large for the patient possessing it. Many tables of normals have been constructed, but they seem to show rather wide variations for each class of individuals listed. In a word, when depending upon tables, it is often necessary to say that the dimensions of a certain heart are at the upper border of normal or, perhaps, a little greater than normal, while the patient seems perfectly well and the roentgenologist hesitates to state definitely that there is real cardiac enlargement present. After applying it to a fairly large series of cases, the author has arrived at the conclusion that the cardiothoracic ratio, as recently advocated by Danzer, gives as much information concerning the size of the heart as do the various tables. Cohn,[7] after examining a series of soldiers, is in full accord with this statement. When using this method, the structure is said to be definitely enlarged when the total transverse diameter, that is, "MR" plus "ML," exceeds one half of the internal diameter of the chest. This ratio is expressed as the quotient obtained by dividing the transverse diameter of the heart by the internal diameter of the chest and can be determined very rapidly without the aid of tables. If only the transverse diameter is needed for this determination, it may seem unnecessary to go further with mensuration, but a study of the following cases will show that the relative values of the measurements "B", "L" and "Gt. Vs." give information of value in certain cardiac disorders. In order to present this work in an orderly fashion, the diseases of the heart will be considered under the headings of the hypoplastic heart, pericarditis, myocarditis, valvular disease, cardio-renal disease, and diseases involving the great vessels. This classification does not include the arythmias or congenital diseases of the heart, because only a very few such cases were studied. All of the congenital cases seen showed cardiac enlargement. All of the drawings, with a few exceptions, were made by tracing the outline of the heart, great vessels, diaphragm and lung fields from the finished teleroentgenograms of actual cases. All the diagnoses, histories and physical examinations except one were taken from the records of the Massachusetts General Hospital.

THE HYPOPLASTIC HEART

The determination of the presence of a hypoplastic or small heart sometimes frees a patient from a restricted cardiac life imposed upon him by some well-meaning physician. Figure 2 represents such a case. The patient had been turned down for the draft because of a definite systolic murmur heard over the precordium. The well-informed clinician now pays little attention to a systolic murmur unless it be accompanied by cardiac enlargement, and when the heart is unusually small, as in this case, the patient may be told with a fair degree of assurance that he has no chronic organic heart disease. It is true that persons who have such small hearts often exhibit the so-called effort syndrome which is so clearly described by Thomas Lewis in his little book bearing that title. Bertnard Smith[8] has recently made a careful study of this subject and finds that the patients that have symptoms for a long time have hearts that are smaller than normal, and that in the teleroentgenograms of such hearts, the angle between the lines "L" and "MR" is greater than the average normal. He also states that the long, narrow

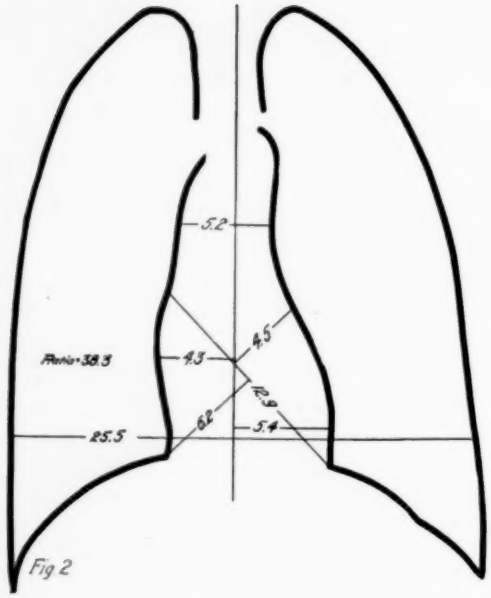


FIG. 2. Hypoplastic Heart. O. P. D. 391673. P. H. Diphtheria, mumps and measles as a child. Has never used alcohol. Tobacco used in moderation. Denies venereal disease. No other important illnesses.

P. I. Has never had any cardiac symptoms but was rejected for the draft because the examining physician found some murmurs.

P. E. Weight 129½ pounds. Age thirty. Apex beat not visible. Impulse forceful and rate rapid as a result of the excitement resulting from examination. No supracardiac dullness. Systolic murmur heard at apex, at second right interspace and in the pulmonic area. Murmur loudest in the aortic area. A_2 sharp and clear; P_2 not accentuated. Second sound at apex clear and pure. Pulses equal and regular and of good volume and tension. Blood pressure 130/80.

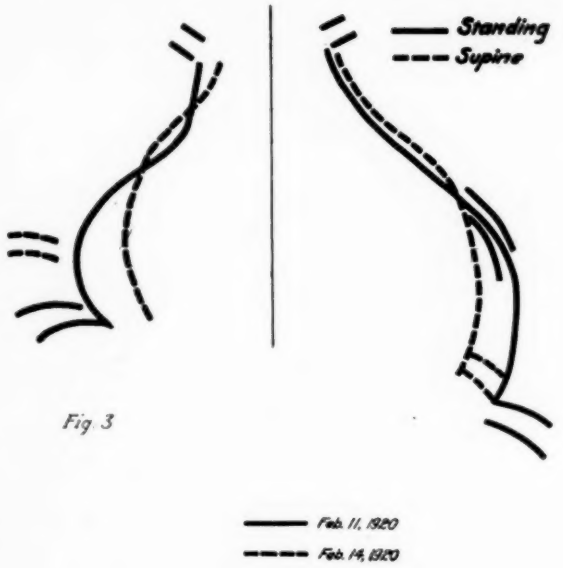


FIG. 3. Pericarditis with Effusion. Case No. 24392. May 3, 1916 (morning). P. I. Had an attack three months ago characterized by pain in right side, productive cough, chills, fever, cold sweats, and palpitation brought on by slight exertion. Says she had fluid in chest but was not tapped. Dyspnea has been constant and increasing in severity since this attack. At times everything "looks black." Fainted four days ago. Unable to rest on left side. Cannot sleep. Too sick to answer questions fully.

P. E. Apex impulse diffuse and not forceful. Question of shifting with change of position. Sounds regular, rapid, and somewhat muffled. P_2 greater than A_2 and accentuated. "To and fro" friction rub in aortic area and well heard to right of apex. No murmurs made out. Both sounds heard distinctly at apex. A few moist râles and increased whispered voice below right scapula behind.

Operation: A needle was put into the pericardial sac in the 5th interspace 3 cm. to the left of the nipple line and directed upward and inward. After penetrating about 1½ inches through the chest well, 90 c.c. of thick, sticky, yellow fluid were removed. The pulse became fuller and slower and varied from 120–130. The dyspnea and cough subsided and the patient was much more comfortable.

"drop heart" is not predominant type, but that the structure may assume a great variety of shapes. It is well to keep in mind the fact that the small heart is thought to be of definite significance only in the patients that have symptoms, for a great many people possessing such small organs do not seem to suffer any great inconvenience therefrom. The effort syndrome is doubtless the resultant of numerous factors in a poorly developed body, the small heart constituting but one of the many.

PERICARDITIS

The diagnosis of pericarditis with or without effusion has long been one of the most difficult problems confronting the clinician and roentgenologist alike. Dr. George W. Holmes[9] has recently published an excellent account of the findings in the former condition, and through his kindness tracings from one of his cases (Figs. 3 and 4) are presented. According to his observations there is in pericardial effusion a change in the shape of the heart shadow with change in position, an obliteration of the normal curves

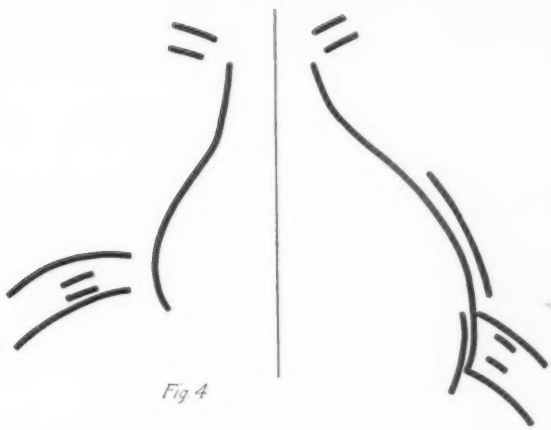


FIG. 4. Pericarditis with Effusion. 26 days after tapping. Question of adhesive pericarditis. Same case as Figure 3. Friction rub still present. Lung signs clearing up. Cardiac dullness much decreased in size. Some anemia. Patient still in bed. Pulse rises when she gets up. Movement of left border of heart seems limited during respiration. Pericardium is probably becoming adherent.

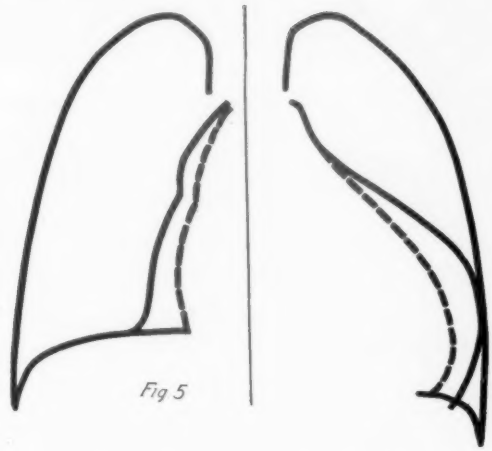


FIG. 5. Acute Dilatation of the Heart. Case No. 235074. Feb. 10, 1920. P. H. Pneumonia as a child. No scarlet fever, tonsillitis, rheumatic fever, or chorea.

P. I. Seven weeks ago she caught a cold and suffered from pain in the chest. After three days she had a cough, chilly sensations, a pain in the side and felt feverish. Was in bed with pneumonia for a month. Got up three weeks ago and has felt pain in right side with a cough ever since.

P. E. Patient is a white girl of thirteen weighing 90 pounds. She has lost seventeen pounds in eight weeks. There are signs of a small amount of fluid at the right base. Heart sounds regular, rapid and of good quality. P_2 greater than A_2 and Sl. accentuated. There is a blowing systolic murmur partly replacing the first sound which is snapping at the apex. Apex shifts in left lateral position. No thrill. Liver dullness extends 5 cm. below the costal margin.

Feb. 15, 1920. Loud friction rub is heard all over the precordia. Loudest just to the right of the sternum in third interspace.

Feb. 24, 1920. Friction rub much diminished.

Feb. 28, 1920. Friction rub no longer heard.

of the cardiac outline and very faint or absent visible pulsation. Fig. 3 represents fluoroscopic tracings made with the patient supine and standing. This case was a long-standing one of tuberculous origin and apparently the pericardium had stretched sufficiently to show considerable change of shape with change of position and had produced the so-called water-bottle appearance. There is some question as to whether an acute effusion of sufficient size to cause tension in the pericardial sac would show this change of shape with change of position. The greatest difficulty in diagnosis arises as a result of the similarity between a pericardial effusion and an acutely dilated heart. They both show a similar shape, faint or absent visible pulsation, and an obliteration of the posterior mediastinal space. The change of shape with change of position does not occur in the case of the dilated heart, and where this change is actually observed a diagnosis of effusion may be made with a fair degree of certainty. Figure 4 represents a fluoroscopic tracing of the cardiac outlines after the disappearance of the effusion shown in Figure 3. The outlines of an acutely dilated heart are shown in Figure 5. The solid line represents the shape which the structure assumed following an attack of pneumonia. The dotted line represents the appearance three days later, when the dilatation had subsided. These drawings were traced from ordinary chest plates made with the same target plate distance. A large effusion would not disappear in three days, and it is because of this fact that the diagnosis was made. It is interesting to note that a friction rub was heard. This is, however, not an unusual finding in acute dilatation of the heart, although it is often interpreted as a sign of pericarditis.

Adhesive pericarditis is no more easily

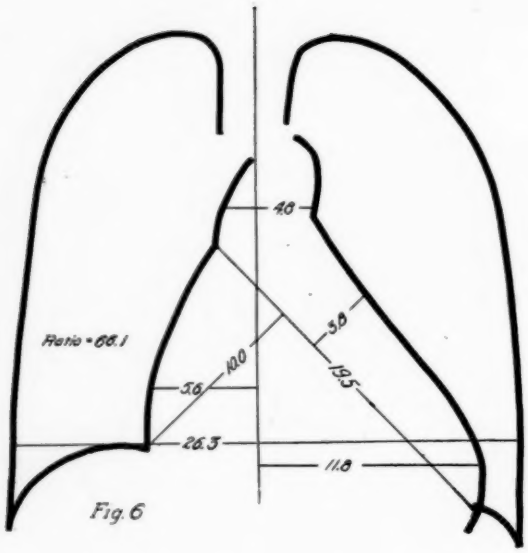


Fig. 6

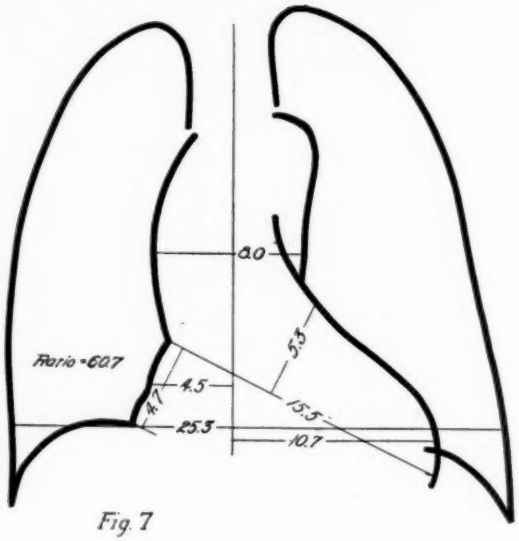


Fig. 7

FIG. 6. Double Mitral Disease with Probable Aortic Involvement, Question of Adhesive Pericarditis. Case No. 231847.

P. H. Diphtheria as a child. Rheumatic fever thirteen times since the age of eight. Many bad sore throats. Chorea at age of eight. An attack of dyspnea lasting six weeks occurred six years ago.

P. I. Influenza nine months ago. Attack of rheumatic fever with severe precordial pain and pain in the lower abdomen of a sharp, cramp-like nature six months ago. Constant sharp pain in lower back and right hip began four months ago. Now has a fever, night sweats, and some precordial pain together with sharp pain in the lower abdomen.

P. E. White man. Age thirty-one. Weight 120 pounds. Purpuric rash on ankles. Heavy apex impulse in the fifth space. Sounds regular and of fair quality. Not rapid. P_2 gretaer than A_2. Blowing "to and fro" murmur over the precordia heard best in the third left interspace and transmitted to the axilla, neck and back. First sound slightly roughened at apex. Second sound replaced by murmur. Pulses corrigan in type. Question of thrill at the apex. Blood-pressure 120/40. Brachials negative. Liver edge 2 cm. below costal margin.

Laboratory Findings. R. B. C. 3,000,000. Hbg. 80%. Wassermann positive. Blood cultures show hemolytic streptococcus at four examinations.

Fluoroscopic Report. Practically no respiratory excursion of the left border of the heart.

Fig. 7. Arteriosclerosis. O. P. D. 392975. P. I. Complains of diplopia which began about eight months ago. Growing steadily worse. Also has supra-orbital headaches and "muscular rheumatism." Troubled with nocturia, polyuria and enceuresis.

P. E. White man. Age seventy-two. Weight not obtained. Left eye turned in. Pupils irregular and very small. Fixed to light but react to distance. Palate reflexes absent. Heart sounds regular and of fair quality. Systolic murmur at the apex and slight systolic whiff at the aortic area. A_2 greater than P_2 and accentuated. Blood-pressure 174/112. Left knee swollen and somewhat tender. Slight numbness of both legs. Marked Romberg. Knee jerks absent. Falls when walking around the house. *X*-ray of left knee shows a narrowed joint space and thickened soft parts. The appearance is that of a chronic synovitis. Clinical diagnosis of tabes was made.

diagnosed than is the type accompanied by effusion. The frequency with which the diagnosis is missed is emphasized by Lyter[10], who describes the findings in thirty autopsied cases. He calls attention to the fact that the left border of the heart should normally move three cm. during deep respiration and should shift three cm. when the patient turns from the right lateral to the left lateral position. The fluoroscopic method of noting the respiratory excursion has already been described. Seven-foot plates made with the patient lying first on one side, and then on the other will demonstrate the lateral shift so that it can be measured. When adhesions occur between the pericardium and the pleura, these two shifts are likely to be diminished or completely done away with. Unfortunately adhesions do not form outside of the pericardium in all cases of pericarditis. When a dense mass of fibrous material forms between the heart and pericardium, the left border often becomes a straight

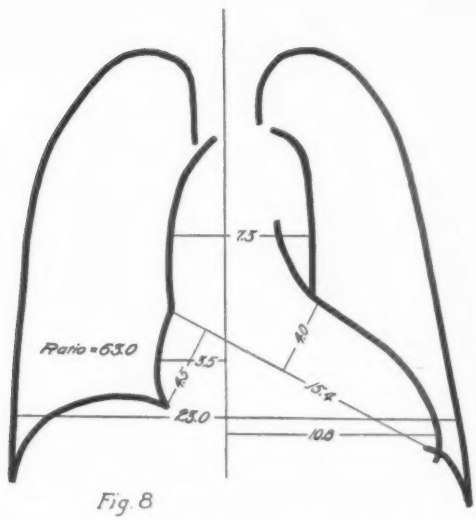


Fig. 8

FIG. 8. Senile Heart. O. P. D. 325755. P. H. Negative except for pain in the back beginning one and a half years ago. Never any nocturia. Cta. ceased fourteen years ago.

P. I. Now complains of constant dizziness and hot flashes. Occasional attacks of palpitation. Considerable pain at times over the eyes and in the back. Intermittent edema of the ankles.

P. E. Patient is a white woman of sixty who weighs 190 pounds. Pulse regular. Rate 80. A_2 accentuated. No murmurs. Blood-pressure 220/104.

Laboratory Tests. Wassermann negative. Urine negative.

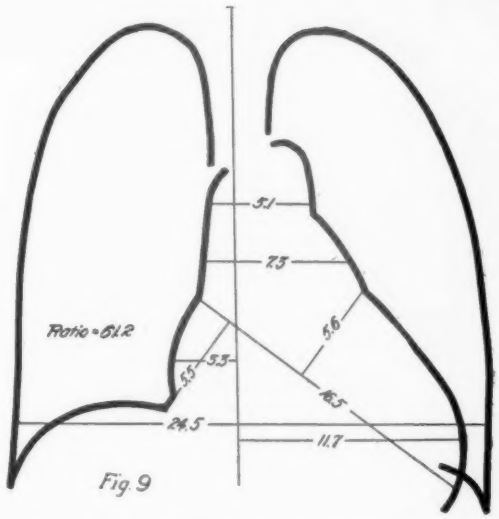


Fig. 9

FIG. 9. Hyperthyroidism. W. M. 11454. Nov. 2, 1916. P. H. Scarlet fever at three. Diphtheria at six. Attacks of tonsillitis almost every year.

P. I. Slight swelling of the neck noticed eleven years ago. Tumor reached present size in four months at end of which time patient noticed that her hands trembled. Exopthalmos appeared two years later. Began to notice rapid, powerful heart action, dyspnea on exertion and excessive moisture of palms about one year ago.

P. E. White woman of thirty-six weighing 139 pounds. Appears to have lost weight. Marked exopthalmos and loss of power of convergence. Thyroid very prominent. Right side more so than left. Definite pulsation. Loud bruit heard over gland. Heart enlarged. P_2 accentuated, louder than A_2 and doubled. Loud blowing systolic murmur at apex transmitted to the axilla and upwards. No edema. Coarse and fine tremor of the hands. Blood-pressure 150/84.

Nov. 23, 1916. Right hemithyroidectomy was done.

Metabolism Reports.

Nov. 3, 1916	+17
Nov. 7, 1916	+57
Nov. 14, 1916	+41
Dec. 16, 1916	+39

line and the cardiac shadow assumes the triangular shape which has been described as a sign of adhesive pericarditis. No pulsations or chamber curves are made out, because figuratively speaking the heart is held in a vice of fibrous tissue. Figure 6 represents such a case in which an endocarditis has gone on to a pancarditis with extensive involvement of the pericardium. Needless to say, all of the cases diagnosed clinically as pericarditis do not show definite roentgen ray signs, but these signs when they do occur are perhaps as definite as any elicited in this malady.

MYOCARDITIS

Myocarditis, that is, a disease of the heart muscle, may result from a great variety of causes, but usually produces definite cardiac enlargement in time. This enlargement is often limited to the ventricles and so produces an increase in the long diameter with some prominence of the curve of the left ventricle. The curves representing the left auricular appendage and pulmonary artery are not, as a rule, distinguishable. Cases illustrating two fairly common classes of chronic myocarditis are cited. Figures 7 and 8 are taken from seven-foot plates of patients possessing senile hearts. Perhaps "cardiosclerosis" is a better term than "senile hearts", for these patients are usually rather aged and show definite arteriosclerosis. They may or may not have a hypertension. Definite symptoms are present and some clini-

cians state that the victim has a "dying myocardium" as a result of a poor blood supply to the cardiac muscle. The aortic arch is usually tortuous and wider than normal, and the pulsations of the ventricles often appear to be feeble. Hearts of this type are likely after a time, to become very long and narrow, and resemble a beef tongue in appearance, the apex corresponding to the tip of the tongue. No evidence of the left auricular appendage can be made out and the whole organ appears to assume a horizontal position in the chest. No roentgenologist is justified in diagnosing this condition from the roentgen ray findings alone, but when such an appearance is encountered in a person past middle age, who shows arteriosclerosis and is complaining of vertigo, dyspnea, palpitation, and perhaps angina, the diagnosis cannot be far wrong. It is a rather interesting fact that the patient whose heart is shown in Figure 7 was said to have tabes. A number of tabetics were examined and almost without exception they showed hearts of this type. They were examined with the hope that they would show definite signs of syphilitic aortitis. It has often been stated that syphilis is an etiological factor in arteriosclerosis and these findings would seem to substantiate this statement because some of the patients examined had not reached the age of forty.

Chronic hyperthyroidism is usually accompanied by a myocarditis which produces definite cardiac enlargement. Such a case is illustrated in Figure 9. Cardiac enlargement was found by the author only in patients who had had symptoms of hyperthyroidism for a number of years. The prominent curve of the left ventricle and the increased length are well shown in the case cited. Many cases show the prominence in the region of the pulmonary artery as shown here. This may possibly represent the border of an enlarged thymus gland. Such an enlarged gland was demonstrated in one such case at autopsy. When the heart has once become affected in these cases, it is in no way benefited by a reduction of the thyroid secretion except in so far as a reduction of the pulse rate may serve to reduce the load carried, and patients may continue to have dyspnea on exertion and some tachycardia after the basal metabolism is reduced to normal, as a result of a myocarditis. The roentgenologist is fairly safe in making this diagnosis in old cases of hyperthyroidism that show definite ventricular enlargement.

VALVULAR DISEASES

A case of acute endocarditis is rarely sent to the roentgen ray laboratory because absolute rest in bed is one of the essentials of treatment and the heart is not so likely to show a characteristic shape during the febrile stage of the disease. However, when the infection subsides and the valve cusps are retracted or stenosed as a result of the formation of scar tissue, the valves begin to leak. This increases the cardiac load and the various chambers become dilated or hypertrophy in an effort to take care of the added work. It is at this stage that the roentgen ray examination should be attempted.

Generally speaking, the valves of the heart are open to two lines of attack. Syphilis beginning in the aorta is likely to move downward and involve the aortic valve, but extends no further along the endocardium. Rheumatic infections, on the other hand, usually begin at the mitral valve and may extend upward to the aortic valve but do not involve the aorta. Other valves may at times be affected, but such lesions are rarely correctly diagnosed before death. An occasional case of rheumatic involvement of the aortic valve alone is encountered now and then.

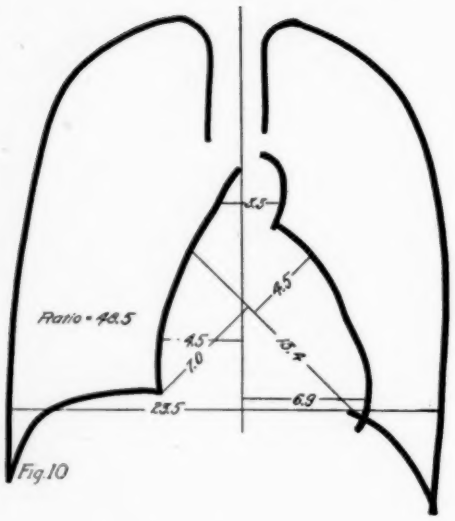
When the mitral valve fails it may show stenosis or a combination of stenosis and insufficiency. Autopsy findings at the Massachusetts General Hospital seem to indicate that pure insufficiency is a rather rare lesion of the mitral valve. No matter what the lesion may be, a failure of the efficiency of the valve disturbs the mechanical balance of

the heart, and blood is either held back or is allowed to regurgitate back into the left auricle. This causes dilatation of that structure and a prominent of the left auricular appendage curve in the roentgenogram. Pulmonary congestion results, and an extra load is thereby thrown upon the right ventricle which in turn passes it back to the right auricle. With an incompetent valve much blood from the dilated left auricle flows into the left ventricle during diastole and causes some increase in the size of that structure. Since the right ventricle pumps blood into the lungs through the pulmonary artery it is also likely to show some dilatation and this helps to accentuate the prominence of the curve of the left auricular appendage, since the shadows of the two structures adjoin one another. The extra load on the right auricle usually causes a marked prominence of the right border of the heart. The enlargement of the right ventricle causes an increase in both the transverse diameter and the distance across the auricles. From this brief description it is evident that the changes produced tend to increase the dimension "B" (equals "X" plus "Y"). When the mitral valve is incompetent "L" may also show some increase as a result of a certain amount of enlargement of the left ventricle; but this is, as a rule, not a striking change.

In examining cases of chronic mitral disease fluoroscopically, it is not at all uncommon to find the lower posterior mediastinal space entirely obliterated by enlarged auricles which extend backward until they come in actual contact with the spinal column. Figure 10 illustrates the findings in a case diagnosed clinically as pure mitral stenosis, whereas Figures 11 and 12 represent double mitral disease. It is interesting to note that in Figure 10 the transverse diameter of the heart does not definitely exceed 50 per cent of the internal diameter of the chest, although the heart has a typical "mitral shape." This is, no doubt, due to the absence of enlargement of the left ventricle. Groedel calls attention to the fact that the cardiac shadow may be relatively small in mitral stenosis, and this is probably the only type of chronic organic heart disease in which the cardiothoracic ratio does not always indicate enlargement. Figure 11 shows a marked prominence of the curve of the right auricle. Figure 12 shows this same prominence combined with an enlargement of the left auricle sufficiently great to obliterate completely the angle normally seen between the descending aorta and the remainder of the left border of the heart. These three drawings illustrate the fact that in mitral disease the dimension "B" approaches the dimension "L" as a limit and as a result the cardiac shadow tends to assume a circular shape. No other cardiac disturbance produces the same series of changes, and when the roentgenologist observes such configuration he is justified in suggesting the diagnosis of mitral disease which should, of course, be checked up by a physical examination.

If the rheumatic infection extends to the aortic valve and a double valve lesion results, the left ventricle of necessity takes up a larger share of the increased load and becomes definitely enlarged. The apex may as a result descend to the level of the sixth interspace in front and on the long diameter is definitely increased. It is only necessary to add to the mitral picture an increased length and a prominence of the curve of the left ventricle to produce the appearance of double valvular disease, as illustrated in Figures 13 and 14. The curve of the left ventricle becomes relatively more and more prominent as we pass from mitral stenosis through double mitral disease to aortic regurgitation.

Pure aortic stenosis is an extremely rare condition and is diagnosed by good clinicians only after much deliberation. The case illustrated in Figure 15 was so diagnosed. It is quite possible that myocarditis is responsible for some of the changes seen. Two points of interest may be noted. The enlargement is limited to the ventricles, chiefly the left, since the distance "B" extending across the right ventricle is not increased, and the aortic



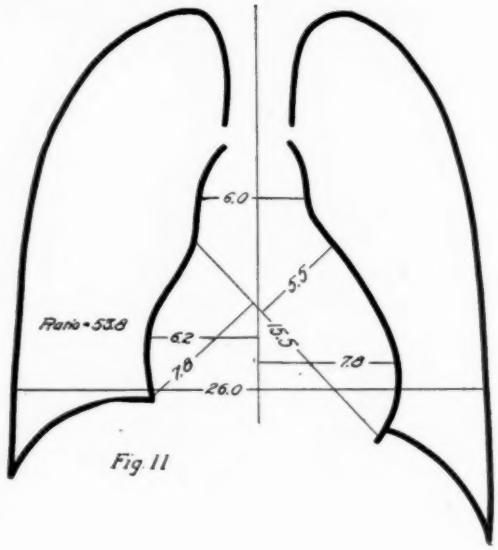


FIG. 10. Mitral Stenosis. Case No. 231751. P. H. No history of children's diseases. For several years has been troubled with attacks of dyspnea, cyanosis, and a choking sensation after exertion. No productive cough or edema. Some attacks accompanied by knife-like precordial pain and a dry cough.

P. I. Balance of past year spent in bed. Attacks characterized by dyspnea, dry cough, cyanosis, palpitation, and sharp precordial pain still occur.

P. E. White girl. Weight, 117 pounds. Sounds regular and rapid. P_2 greater than A_2 and accentuated. Pre-systolic roll at apex. First sound loud and sharp. Slight systolic and loud rough diastolic murmur at apex transmitted to axilla. Slight thrill in fifth interspace. Blood-pressure 110/65.

Laboratory Findings. Renal function 50 per cent. Wassermann negative.

FIG. 11. Mitral Disease (probably double). Case No. 232110. P. H. In bed with rheumatic fever one month, four years ago. Scarlet fever followed by rheumatic pain which kept him in bed ten weeks, seven months ago. Venereal denied. No tobacco or alcohol.

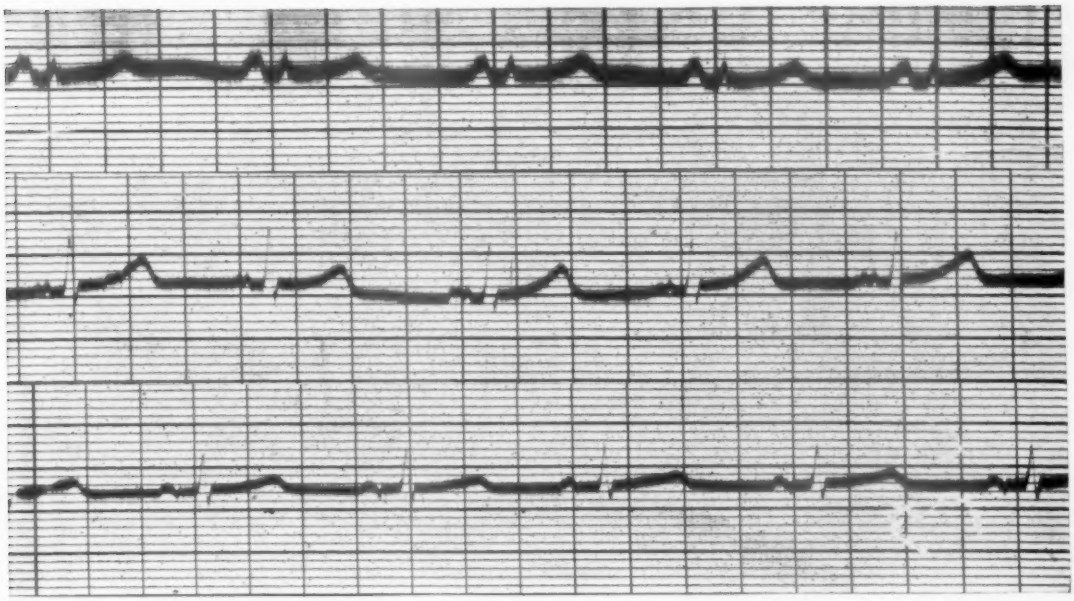
P. I. Turned down by draft board about one year ago. Dyspnea and palpitation followed attack of scarlet fever and rheumatism seven months ago. No edema. Chief complaint at present is dyspnea, weakness and palpitation following exertion.

P. E. White man. Age twenty-one. Weight 138. Mucous membrane cyanotic. Tonsils red, large and ragged. Venous pulsations seen in neck. Cervical glands palpable. Heart impulse heaving and diffuse, and seen in 4th interspace. Sounds regular and slightly rapid. First sound replaced by systolic murmur, transmitted to axilla, precordia and back. No definite thrill. P_2 greater than A_2. Reduplicated and accentuated. Arterial walls not palpable. Brachials not tortuous. Blood-pressure 140/70. Knee jerks present and equal.

Laboratory Findings: Urine negative. Wassermann negative.

arch is normal in size and shape. The normal arch makes the presence of syphilitic aortitis, cardio-renal disease with hypertension, or arch sclerosis rather unlikely, and it is therefore necessary to explain the ventricular enlargement as resulting from a rheumatic infection of the aortic valve, a myocarditis, or an aortic stenosis. It is very unlikely that any roentgenologist would be so rash as to hazard the correct diagnosis on the basis of the roentgen appearance alone.

Aortic valve involvement is in a large majority of adult cases due to syphilis and its onset is likely to be preceded by a syphilitic aortitis of the ascending aorta. Figure 16 illustrates an advanced case of this type. There is a marked increase in the width of the aortic arch and a prominence in the lower part of the ascending portion which probably represents a localized dilatation. The heart is very long and lies transversely in the chest as a result of a high diaphragm. The auricles are not enlarged, but the curve of the left ventricle is very prominent. The distance across the base "B" is not outside normal limits, and it may be inferred that the left ventricle is enlarged much more than the right. Left ventricular preponderance is often present in cases of aortic regurgitation.



GRAPH. I. Illustrating Figure 10. Broad notched "P" wave of the type often seen in mitral stenosis.

CARDIO-RENAL DISEASE

A patient with damaged kidneys who has maintained a high blood-pressure for a long time must of necessity possess a large hypertrophied heart if he is to keep his bodily machine operating. If the hypertrophy is not sufficient to meet the heavy demands of a high blood-pressure, he suffers from various cardiac symptoms. The hypertrophy is usually pretty well distributed between the two ventricles, and as a result such hearts become enormous in size. Figures 17 and 18 show fairly typical cases. The aortic knobs are prominent, perhaps as a result of arteriosclerosis, which is often present in cardio-renal disease. Although the curves representing the auricles are not at all prominent, the distance "B" is outside normal limits and this seems to indicate the presence of a definite hypertrophy of the right ventricle. The increased length of the heart and the prominence of the curve of the left ventricle point toward hypertrophy of that structure. The roentgenologist is not always justified in describing an increase in cardiac size as due to hypertrophy rather than dilatation, but in these cases the vigorous pulsations observed fluoroscopically seem to point in that direction. Early cardio-renal cases do not show such pronounced changes and may be easily confused with other conditions causing ventricular enlargement.

DISEASES INVOLVING THE GREAT VESSELS

This subject was more fully covered in a previous article[11], but this survey of diseases of the heart would hardly be complete without some reference to it. Many of the drawings shown here were used in the previous article. It is probably true that a large number of cardiac cases are sent to the roentgenologist because the clinician is afraid that he may be overlooking a syphilitic aortitis or to check up his diagnosis of that condition. The diagnosis of aortitis should be made with the greatest caution in cases showing widened shadows of the great vessels. Arteriosclerosis, hypertension, chronic mitral disease, a high diaphragm, or an enlarged pulmonary artery may produce widened shadows of the great vessels.

Figure 19 illustrates a typical wide, tortuous aortic arch of the type seen in advanced arteriosclerosis. The widening is apparently due to the fact that the descending aorta swings to the left. The aortic knob

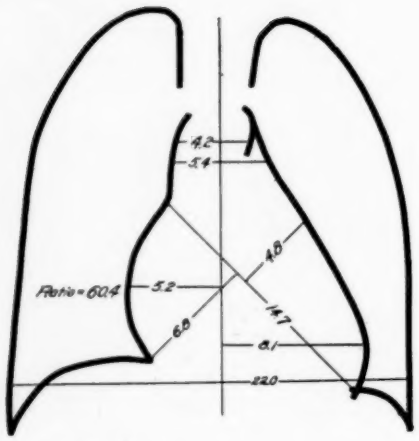


Fig. 12

FIG. 12. Mitral Disease and Chorea. O. P. D. 244944. June 13, 1914. P. H. Negative except for scarlet fever five months previously.

P. I. Has complained of tenderness on being touched for several weeks. Is very nervous and rather weak.

P. E. Patient is a white girl seven years of age. Tonsils are ragged and protrude. Heart is swollen. Heart is not enlarged. Sounds regular and of good quality. No murmurs heard. No swollen or tender joints. Considerable choreiform movement.

Mar. 20, 1920. P. E. Heaving apex impulse in the 5th space 10 cm. to the left of the midsternum. Loud systolic murmur at the apex partly masking the 1st sound. Pulmonic 2nd sound very loud and reduplicated at the apex. Slight diastolic rumble when the patient lies down.

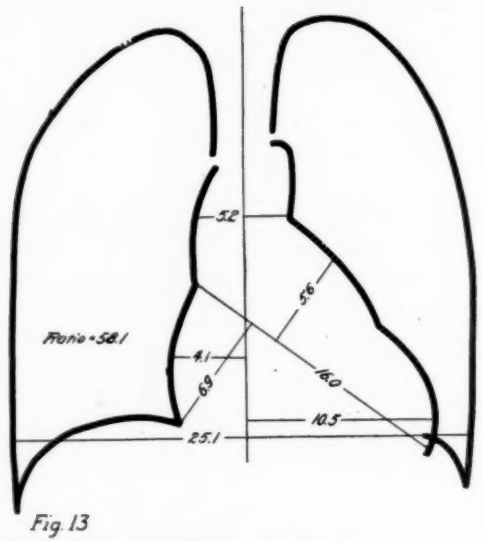


Fig. 13

FIG. 13. Double Mitral Disease and Aortic Regurgitation. O. P. D. 392730. P. H. Has had attacks of rheumatic fever and sore throats during the past year. No other serious illnesses.

P. I. Comes in complaining of pain in all of the joints of the body which has been worse during the past three months. Dyspneic after climbing a flight of stairs. Occasional edema of the ankles.

P. E. The patient is a white man of twenty-four who weighs 140 pounds. Heart sounds regular. There is a loud blowing systolic murmur heard all over the precordia with a maximum intensity at the apex. The murmur is transmitted to the axilla. P_2 is accentuated. There is an early diastolic murmur heard just to the left of the sternum in the 3rd interspace. The apex is felt in the 6th space. The apex impulse is felt in the 6th space.

Laboratory Tests. Wassermann negative.

is usually prominent in arch sclerosis even though it be partially obliterated by the shadow of the descending portion of the vessel. If the patient be rotated to the left in the fluoroscope until the shadow of the ascending aorta overlies that of the descending aorta, the transverse dimension of the resultant shadow should not seem too large. It is often possible to take plates in the left oblique position which show the entire ascending, transverse, and descending thoracic aorta. The heart illustrated in Figure 19 might be said to be a sequela of cardio-renal disease, but the nephritis is probably arteriosclerotic in origin, and the sclerosis of the arch may have preceded the nephritis.

Arteriorsclerosis is to be expected in the aged; but younger people sometimes have it. A case of arteriosclerosis with hypertension and a wide, tortuous, aortic arch is shown in a woman of thirty-nine in Figure 20. A girl in the early twenties with a similar condition was also observed. These cases of precocious arteriosclerosis are not so uncommon as one might suspect, and it is just such a case that is most likely to be branded as syphilitic when a wide arch is discovered.

The obese patient almost always shows a wide area of supracardiac dullness, and in many cases this is due to the high position of the diaphragm. Figure 21 shows three wide arches observed in obese persons and also the widening of the arch resulting from forced expiration in an individual of average size. The position of the diaphragm should be carefully observed in aortitis suspects.

The effect of chronic mitral disease on

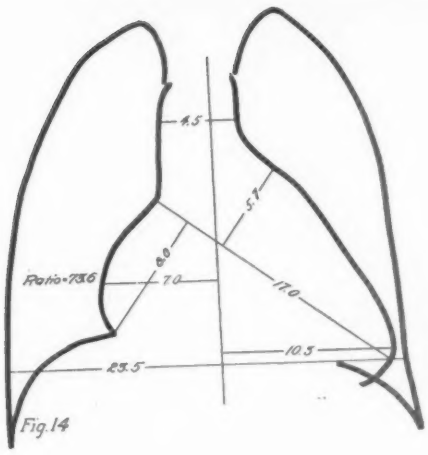


Fig. 14

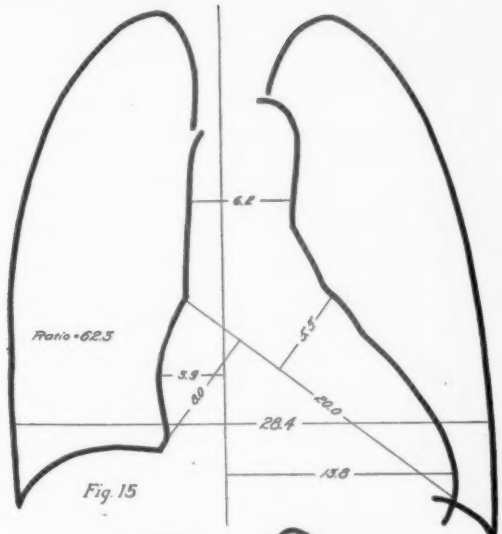


Fig. 15

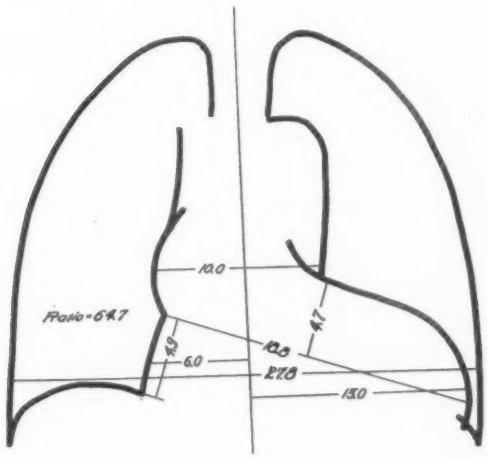


Fig. 16

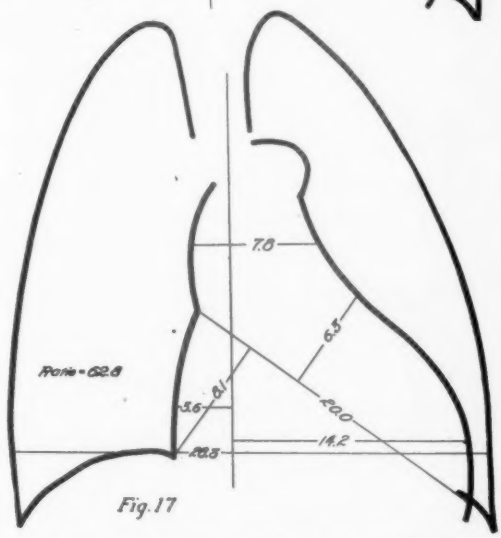


Fig. 17

FIG. 14. Double Mitral Disease and Aortic Regurgitation. P. H. In bed with polyarticular rheumatism eleven years ago. Similar attacks since. Influenza and pneumonia nine months ago.

P. I. Pain appeared in precordia and right shoulder two years ago. Became dyspneic on exertion eleven months ago after an attack of influenza. A severe rheumatic attack occurred one month ago.

P. E. Apex impulse in 5th space. Sounds of good quality. Occasional premature beat. P_2 greater than A_2 and much accentuated. Loud blowing systolic and diastolic at the apex. "To and fro" murmur at the base. Arterial walls palpable. Thrill at the apex. Blood-pressure 126/60. Wassermann negative. Age, twenty-six. Weight 104 pounds.

FIG. 15. Aortic Stenosis. Case No. 230864. P. H. A painter for thirty years. Lead colic sixteen years ago. Gonorrhea at twenty. Syphilis denied. Much alcohol up until ten years ago.

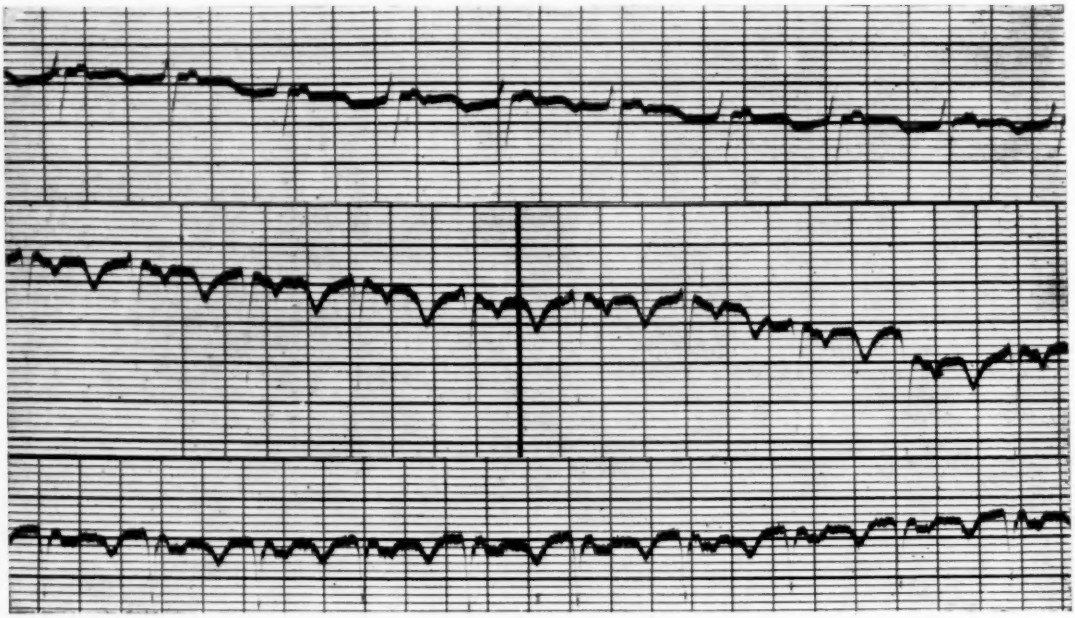
P. I. Three years' duration beginning with dyspnea and palpitation. Aching pains in legs began eighteen months ago, worse in evening. Cough began five months ago. Edema of ankles for past three weeks with cyanosis and dyspnea on exertion.

P. E. Age fifty-eight. Weight 144 pounds. Brachials sclerosed. Harsh blowing systolic murmur at base, heard best in aortic area and transmitted to neck. Double murmur at apex which disappeared after rest in bed. Systolic thrill in aortic area. Blood-pressure 115/90. Wassermann negative. Electrocardiogram shows left ventricular preponderance and premature ventricular contractions.

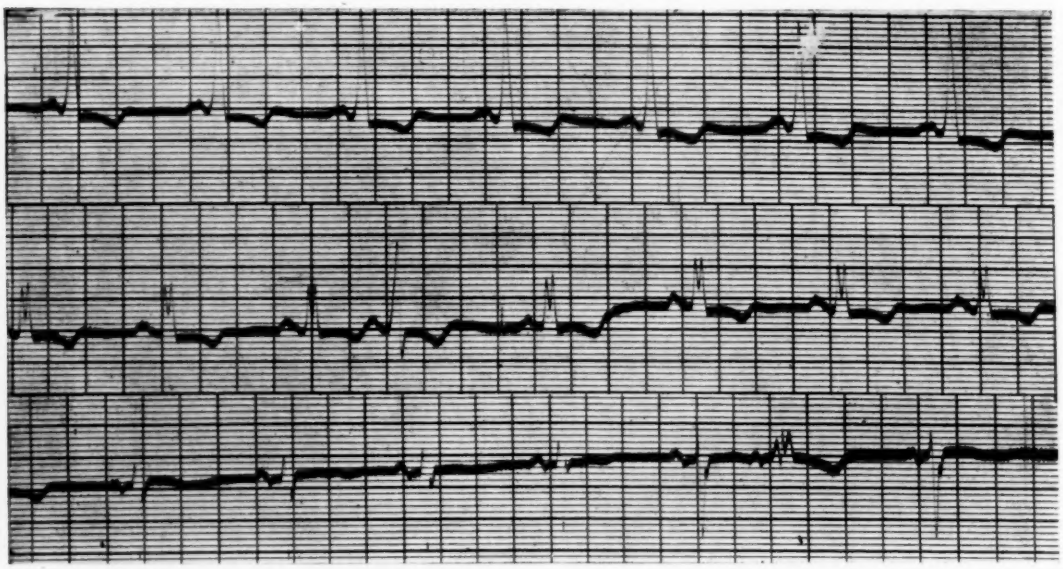
FIG. 16. Syphilitic Aortitis and Aortic Regurgitation. O. P. D. 404570. P. H. Has had pneumonia twice. Gonorrhea twenty-five years ago. Married thirty years. Wife has never been pregnant.

P. I. Has suffered from epigastric distress, dyspnea, and palpitation on exertion for about eight months. No edema.

P. E. Negro man. Age sixty-one. Weight 185 pounds. Blood-pressure 200/80. Knee jerks absent. Pupils sluggish. Brachial arteries sclerosed and tortuous. Corrigan pulse. Double murmur in the aortic area. Diastolic murmur to the left of the



GRAPH II. Illustrating Figure 14. Tachycardia. B road notched "P" waves in all leads.



GRAPH III. Illustrating Figure 15. Left ventricular preponderance. Right ventricular premature contractions. Aberrant ventricular contractions. Invert "T" wave. "P" wave broad and notched in leads I and II.

sternum. A_2 absent. Pistol shot sound in the groin. Visible pulsations in the neck.

Laboratory Findings. Urine not definitely abnormal at one examination.

FIG. 17. Cardio-Renal Disease. Case No. 231934. P. H. Diphtheria at twenty-five. Tonsillitis at same time. Syphilis at age of twenty. Does not drink steadily but goes on alcoholic sprees.

P. I. Nocturia began one year ago; has gotten progressively worse. Severe frontal morning headaches began seven months ago. Attacks of dyspnea during past seven months. Blurring of vision and spots before the eyes for past three months. Dizzy vomiting spells for past two months. Cramps in legs recently.

P. E. White man. Age forty-nine. Weight 150 pounds. Sounds regular and rapid. P_2 greater than A_2. Both accentuated. Soft systolic murmur over precordia heard best in the 4th left interspace. Pulses equal and of high tension. Arterial walls palpable. Blood-pressure 210/140. Brachials tortuous. Fundi show albuminuric retinitis.

Laboratory Findings. Renal function 10 per cent. Wassermann negative.

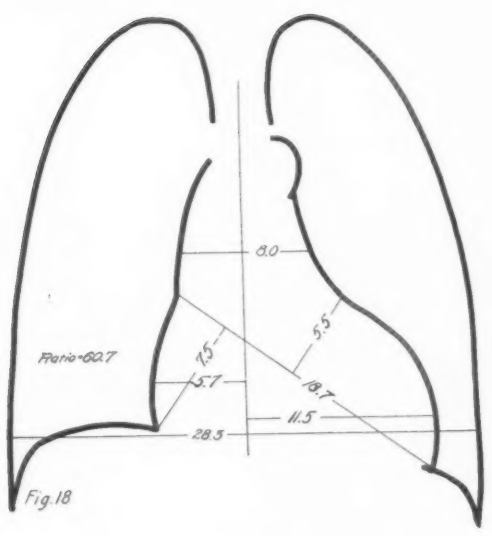


FIG. 18. Cardio-Renal Disease. Case No. 233130. P. H. No diseases except scarlet fever in childhood. Always a heavy meat-eater. Used much alcohol up until two years ago. A heavy smoker.

P. I. Began to complain of dyspnea and a "lazy" feeling about three years ago. Has been in the hospital twice before because of worn out feeling. Orthopnea became noticeable two weeks ago and was accompanied by nocturia and edema of the ankles, lower legs, and thighs. No precordial pain at any time.

P. E. White man fifty-two years old, weighing 196 pounds. Jan., 1917. Sounds regular and of good quality. Rate normal. Soft systolic at the apex. Second sounds accentuated. Liver edge felt 2 cm. below the costal margin. Electrocardiogram showed left ventricular preponderance. Wassermann negative. Renal function 30 per cent. Urine showed a Sp. Gr. of 1020-24, albumin V. S. T. to S. T., and many hyaline casts. Blood-pressure 180/110.

May, 1919. P_2 equals A_2. Shrill high pitched murmur in the mitral area. No thrill. Brachials tortuous. Blood-pressure 210/140 to 230/140. Renal function 20 per cent to 25 per cent. Urine showed hyaline and granular casts and a Sp. Gr. of 1012 to 1020.

Oct., 1919. Second sounds accentuated. Blowing musical systolic murmur at the apex transmitted to the axilla. Radial arteries sclerotic and beaded. Blood-pressure 220/150. Râles in bases of lungs. Edema of angles and thighs. Fundi showed sclerosed and tortuous arteries and small sclerotic plaques. Urine shows a Sp. Gr. of 1010-14, a T. to V. S. T. of albumin and hyaline and granular casts. R. F. 25 per cent. Hbg. 70 per cent.

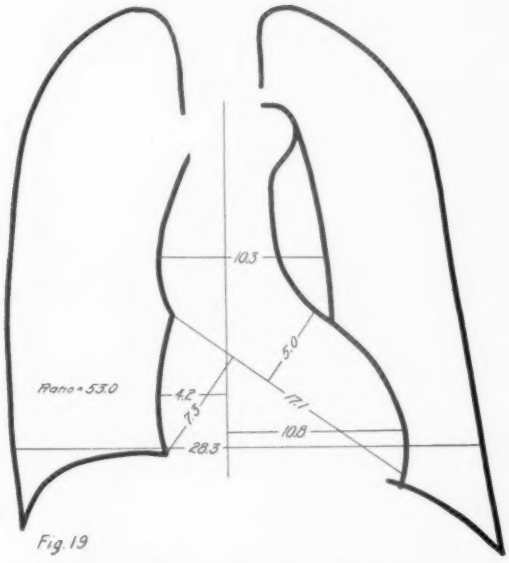


FIG. 19. Arteriosclerosis with Nephritis. Case No. 232022. P. H. Scarlet fever in childhood. Sick several months twenty years ago with nausea, diarrhea, vomiting and abdominal pain. "Grippe" four years ago. Generalized edema with headache, blurring of vision and delirium three years ago. A "shock" occurred one year ago. Unconscious for twenty-four hours. Some weakness in left arm and leg since. Venereal denied.

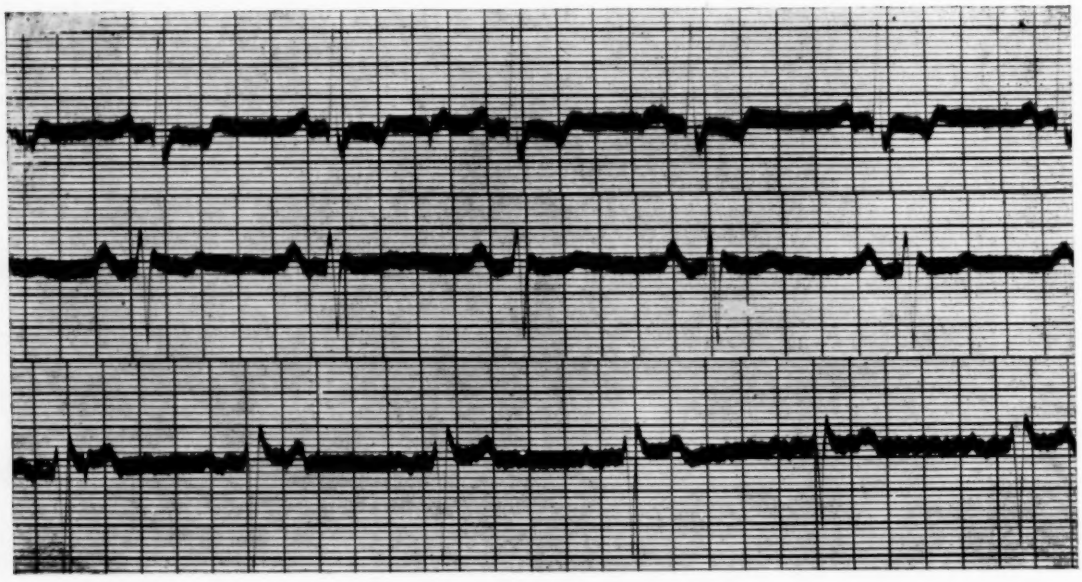
P. I. Feels weak and tired. Still has weakness of left arm and leg. Has attacks of dizzy sensations accompanied by vomiting, a feeling pressure in the head, and a general numb feeling.

P. E. White man. Age sixty-four. Weight 175 pounds. Pupils irregular. Cardiac impulse seen and felt in the 6th space. No thrills. Sounds regular and of fair quality but rapid. A_2 greater than P_2 and accentuated. No murmurs. Arterial walls palpable, brachials not tortuous. Blood-pressure 208/120. Knee jerks normal.

Laboratory Findings. Urine shows a trace of albumin, a Sp. Gr. of 1020 to 1023 and a frequent hyaline and granular cast at two examinations. R. F. 12 per cent. Wassermann negative.

the contour of the left border of the cardiac shadow has been discussed under the subject of "Valvular Disease." In Figure 12, the supracardiac dullness is shown definitely increased as a result of dilatation of the pulmonary artery and left auricular appendage. The clinician is very familiar with the increase in percussion dullness to the left of the sternum with the enlargement of the left auricle. Such cases present a fairly typical cardiac shadow and are not likely to be confused with aortitis.

The increased width of the supracardiac shadow accompanying chronic hypertension is well brought out in Figures 17 and 18. Smith and Kilgore[12] have called attention to a series of such arches in cases of cardio-



GRAPH IV. Illustrating Figure 18.

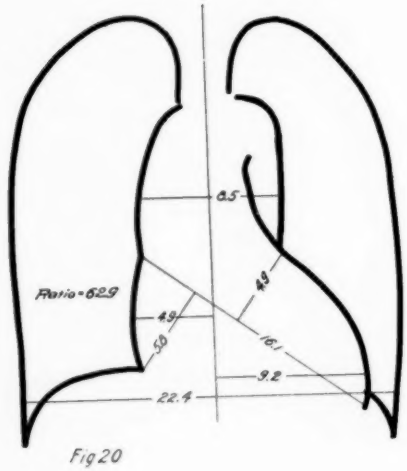


Fig 20

FIG. 20. Precocious Arteriosclerosis with Hypertension. Case No. 233568. P. H. No rheumatic history. No miscarriages. Venereal denied. "Tubes and ovaries" removed eleven years ago for pelvic abscess.

P. I. Weak and tired and subject to "hot flashes" and "cold sweats" since the age of eighteen. Dyspnea began three years ago. About two years ago she began to have palpitation and severe headaches accompanied at times by vomiting, dizziness, staggering, stars before the eyes and on two occasions everything turned black before her eyes. During the past year the above symptoms have been less but there has been some edema of the ankles and a numb feeling in the right leg and arm at intervals. No nocturia or other urinary symptoms.

P. E. Patient is a pale white woman, age thirty-nine, weighing 112 pounds. Marked venous pulsation in neck. Sounds regular and rapid and of good quality. A_2 is greater than P_2 and much accentuated. Reduplicated 1st sound and a systolic murmur at the apex transmitted to the axilla. Systolic murmur in the aortic area not transmitted. Very questionable thrills observed at the apex and at the aortic area. No presystolic murmur. Arterial walls palpable. Brachials tortuous. Blood-pressure was 270/190 six months ago and is 210/140 now.

Laboratory Findings. Urine shows nothing abnormal except S. P. T. of albumin and a rare white cell at numerous examinations. No fixation of gravity or retention of chlorides. Renal function 60 per cent. Non-protein nitrogen 35.9 mgs. per 100 c.c. of blood. Wassermann negative twice.

renal disease with hypertension, in which no evidence of syphilitic infection could be found. It has been claimed that the widening is due to a dilatation of the aorta resulting from the long continued high blood pressure. Some think that arteriosclerosis is also a factor. No matter what the etiology may be, it is a proven fact that the transverse dimension of the great vessels in such cases may measure 7, 8, or even 9 cm.

A dilatation of the pulmonary artery is only met with occasionally, but when it occurs, the appearance is very typical and produces a definite widening of the shadow of the great vessels resulting from a sharply defined prominence in the region of the pul-

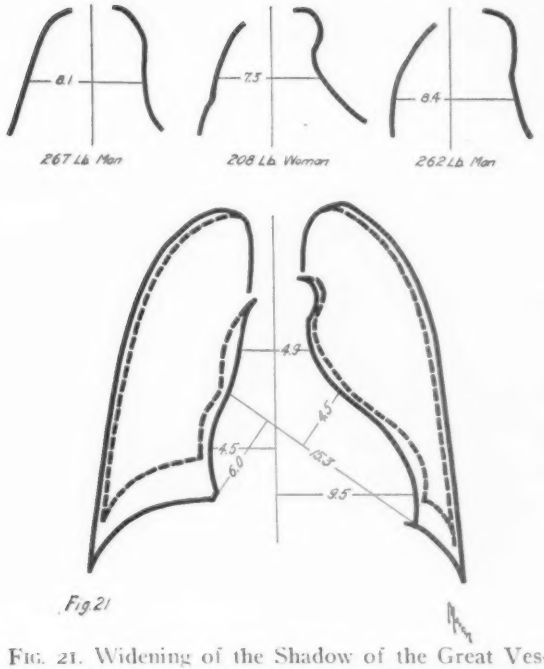


FIG. 21. Widening of the Shadow of the Great Vessels Due to a High Diaphragm. The three upper tracings represent the size and shape of the great vessels in patients weighing over 200 pounds. In each case there was a high diaphragm probably due to a large amount of abdominal fat. These sketches are traced from the seven-foot plates. In well built individuals weighing over 200 pounds and possessing a normally placed diaphragm the great vessels rarely measure over 6 cm. in width.

The large drawing represents the shape and size of the heart, great vessels, and thoracic cavity of a well built man thirty-nine years of age and weighing 142 pounds. The solid outline was made from a seven-foot plate taken during normal breathing while the broken outline was traced from a seven-foot plate of the same patient during forced expiration. This man was a recently discharged soldier who had been leading an active life and he had a good diaphragmatic excursion. During expiration the diaphragm rises and the chest walls are drawn in. The heart is forced upwards but apparently the upper portion of the aortic arch remains fixed. As a result the heart and great vessels are compressed and a widening of their transverse diameters results.

This patient came in complaining of a feeling of fullness in the chest which was worse after meals and had been present for about a year. There were no other symptoms. On auscultation there was a double murmur in both the aortic and mitral areas and A_2 was sharp. The pulse pressure was a little higher than normal. There was no rheumatic or syphilitic history. The electrocardiograph showed nothing abnormal. He was thought to have an early involvement of both the aortic and the mitral valves of rheumatic origin.

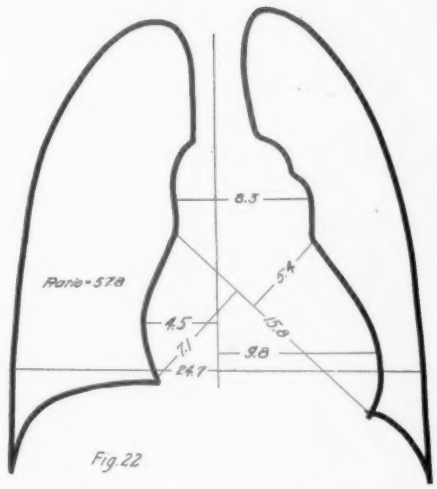


FIG. 22. Dilated Pulmonary Artery. Case No. 145038. P. H. Croupous pneumonia at twelve. Typhoid and diphtheria at thirteen. Question of bronchopneumonia at twenty-five. No rheumatic history. Question of chancroid eight months ago. In the hospital with a "cold" for two weeks about four months ago. Has been working but never "up to snuff." Some precordial pain and dyspnea for past two years.

P. I. Has complained for the past four days of headaches, "hot and cold" sensations, pains all over the body, and a cough accompanied by pain in the left lower chest. This condition was diagnosed as a mild bronchopneumonia.

P. E. White boy twenty-six years old weighing 124 pounds. At the age of twelve: Heart outside the nipple line three and one half inches from the mid-sternum. No increase to the right. Action rapid and regular. Second sound at apex accentuated. P_2 equals A_2. Systolic murmur at the apex not transmitted. In the hospital with croupous pneumonia at this time.

At the age of thirteen: Heart in the 5th space in the anterior axillary line. No increase to the right. Action rapid and regular. P_2 very much accentuated and equals A_2. First sound replaced by a systolic murmur heard all over the precordia, loudest in the mitral area and transmitted to the axilla. Spleen palpable. In the hospital at this time with diphtheria and typhoid.

At the age of twenty-five: Heart apex impulse felt and seen 12 cm. to the left of the mid-sternum line. Sounds regular and of poor quality. P_2 is accenuated and reduplicated and equals A_2. Short systolic murmur at the apex transmitted to the axilla. Short diastolic just to the left of the sternum. Blood-pressure 110/60. *X*-ray showed a prominence of the pulmonary artery and a thickening of the hilus shadows and lung markings. Diagnosis, mitral insufficiency and question of broncopneumonia at this time.

At present: Impulse heaving. Sharp slap felt half way between the pulmonary area and the apex. P_2 greater than A_2 and much accentuated. Soft systolic murmur at the apex. Second sound loudest where slap is felt, and synchronous with it. No thrill. Blood-pressure 148/110. Sputum shows Type IV pneumococcus and blood culture shows staph. albus.

GRAPH V. Illustrating Figure 22. Marked right ventricular preponderance, a condition found most commonly in mitral stenosis, congenital heart, and chronic pulmonary disease of a type causing pulmonary artery dilatation.

monary artery. Such a picture may be obtained with a patent ductus arteriosus, a pulmonary stenosis, or an aneurysm of the pulmonary artery. It is conceivable that some form of obstruction to the pulmonary circulation might cause it. A patent ductus arteriosus is probably the most common cause. Figures 22 and 23 show rather typical cases. Hubeny[13] has written an excellent description of this condition. The appearance is so striking that the diagnosis is probably very rarely missed. An enlarged gland in the left hilus or a small sharply localized aneurysm in the descending aorta might conceivably give a similar picture, but in such cases the physical signs would be entirely different.

Syphilitic aortitis unfortunately does not always produce so typical an appearance. Of course it is impossible to detect any roentgen ray evidence of the disease until it has progressed far enough to produce some changes in the shape of the aorta. In a certain number of cases (not over 30 per cent of those coming to autopsy) the involvement is limited to the region just above the aortic valve, and a localized dilatation occurs at this point. Such a dilatation produces a prominence in the ascending aorta just above the aortic valve lesion. The discovery of these dilatations is of great diagnostic value. However, the diffuse dilatations produce pictures which resemble many other conditions, and all of the obtainable clinical evidence is needed in attempting a diagnosis. Figure 26 illustrates such a condition. If the aneurysms had not been discovered, this arch would in all probability have been called arteriosclerotic, and no doubt the patient had definite arteriosclerosis. However, it seems fair to assume that a syphilitic infection general enough to involve vessels in the neck and in the abdomen would hardly miss the aortic arch.

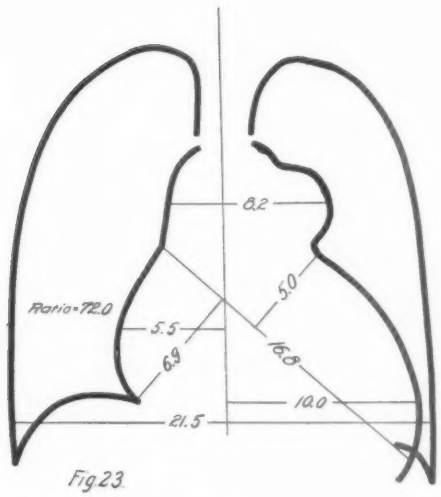


FIG. 23. Dilated Pulmonary Artery. (Case seen at Baylor Hospital, Dallas.) P. H. Mother states that doctors were interested in the child's heart shortly after birth. There have been several febrile attacks of an unknown character.

P. I. Patient is semistuporous and a good history is not obtainable. Mother thinks that patient was fairly well until three months ago when she began to complain of dyspnea and orthopnea. At present she is coughing up a bloody sputum and running a temperature ranging between 99 and 103 degrees F.

P. E. The patient is a fairly well developed negro girl thirteen years of age. At admission the temperature was 103, the pulse 144 and the respiratory rate 46. Râles are heard in the lower left axilla. The left side of the chest is slightly more prominent than the right and a diffuse heaving impulse can be seen covering most of the precordia. The heart is definitely enlarged to percussion both to the right and to the left. A systolic thrill is felt in the pulmonic area. The pulmonic second sound is accentuated and reduplicated. There is a loud systolic murmur heard loudest in the pulmonic area and transmitted upwards on both sides of the neck but best on the left. The white count is 34,800. The urine shows a few hyaline casts and pus cells.

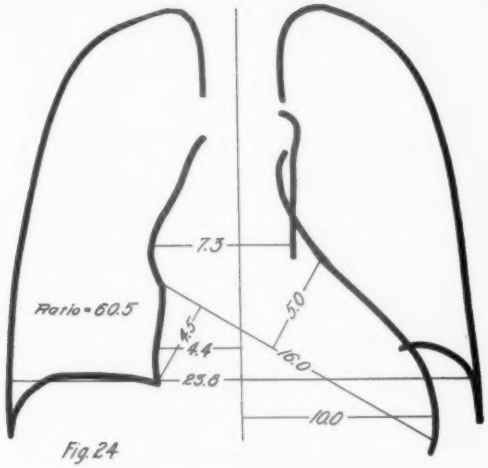


FIG. 24. Specific Aortitis Long Unrecognized. O. P. D. 181357. 1911. Jewish woman of fifty weighing 155 pounds comes in complaining of continual cough with non-purulent sputum, dyspnea, pain in the throat and back, and some incontinence of urine. Examination shows A_2 accentuated, heart not enlarged to percussion, a blood-pressure of 150 (systolic) and the bases of the lungs full of râles. A diagnosis made of bronchitis.

1912. Cough still present. Worse at night. Raises little. Feels weak. No murmurs made out in heart examination. Blood-pressure noted at 130/80.

1913. Cough worse but non-productive. Marked dyspnea on exertion. A_2 greater than P_2. Soft systolic murmur heard in aortic area. Blood-pressure noted as 135/90.

1914. Old symptoms still present. Pain has appeared in left back and in wrists and ankles.

1915. Blood-pressure noted as 180 (systolic). Treated in dental clinic for apical abscesses. Treated in throat room for pain in throat without a definite diagnosis. Treated in orthopedic department for pains and wrists and ankles. All of this treatment failed to clear up original symptoms.

1916. Admitted to the hospital for study. Wassermann negative. Discharged after a week with diagnosis of: Question of cholecystitis, chronic pyelitis, cystitis, and a question of mitral disease.

1917. Admitted to hospital a second time. Discharged with the diagnosis of: Senile heart, chronic arthritis, obesity, and a question of myxedema. Blood-pressure noted as 140/90.

1919. Comes in complaining of hoarseness, cough, a feeling of anxiety, dyspnea, and some palpitation. Examination of the heart shows the sounds regular and distant, a systolic murmur heard all over the precordia and transmitted to the neck, and a diastolic murmur in the aortic area.

DISCUSSION

These few cases show in a general way the more striking morphological differences in various types of cardiac pathology. Prognosis and treatment are now based to a large extent on hypertrophy and dilatation, that is on the condition of the cardiac muscle rather than on the nature of the lesion present. Accurate records of changes in size and shape taken at regular intervals are of the greatest value to the cardiologist. Those who refuse to avail themselves of such aid are merely disregarding one of the more accur-

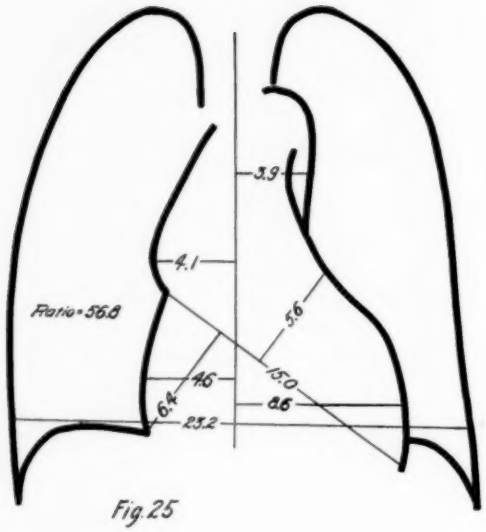


Fig. 25

FIG. 25. Specific Aortitis and a Tremor of Syphlitic Origin. O. P. D. No. 392668. P. H. Has had typhoid, scarlet fever, and gonorrhea. Also a penile sore some years ago.

P. I. Slight tremor appeared in left arm five years ago. Remained constant and of the same intensity for three years. It then extended to the left leg and right arm two years ago and has been getting worse. Some shooting pains recently in legs. Otherwise feels well and strong.

P. E. White man. Age forty-three. Weight 140 pounds. Left arm shows a constant tremor. Right arm and left leg show the same phenomenon to a less degree. Tremor diminishes while performing purposeful movements. Right pupil slightly irregular. No reaction to light and distance. Slight systolic murmur in the aortic area. A_2 greater than P_2. Blood-pressure 170/110. Lungs negative. Knee jerks absent.

Laboratory Findings. Blood Wassermann moderately positive. Spinal fluid shows 31 cells per cubic millimeter, an increased pressure, and a strongly positive Wassermann reaction.

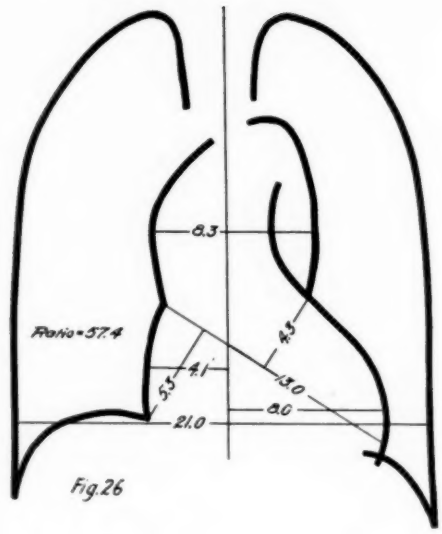


Fig. 26

FIG. 26. Multiple Aneurysms. Case No. 231966. P. H. No children's diseases. One child lived to be twenty-one but died of tuberculosis. Four miscarriages. "Gastric catarrh" evidenced by abdominal distress and backache for many years. Married thirty years. Says husband is well. No alcohol.

P. I. For past five months she has had an attack of dizziness and vomiting about once a week. Attacks last one or two days. Well between attacks. At times she has a pain in the back which is made worse by exertion and on several occasions has been transmitted down the arm (left) and accompanied by tingling in the fingers. Progressive loss in weight, 70 pounds in four years.

P. E. White woman. Age fifty. Weight 100 pounds. Small pulsating mass felt and seen in the base of the neck on the right side. Systolic bruit heard over this tumor. Firm, round, somewhat tender pulsating mass in upper right quadrant of abdomen about the size of an orange. No bruit heard over this tumor. Heart sounds regular, rapid and of fair quality. A_2 greater than P_2. Slightly accentuated. Loud blowing systolic murmur at the base heard best over the aortic area and transmitted to the neck. No thrills. Blood-pressure 225/140. Arterial walls palpable, tortuous, and markedly sclerosed. Urine shows a slight trace of albumin and a few red and white cells at two examinations. Red count 3,000,000. Hbg. 70 per cent. Wassermann negative.

ate scientific methods at their command.

It may perhaps be wise to utter a word of warning to the enthusiastic roentgenologist who would attempt cardiac diagnosis. Clean-cut cardiac lesions are not particularly common, and the combined lesions that may appear often tax the skill of the best internist with his various methods of investigation. Certain stages in various cardiac disorders produce shapes of the heart outline that are almost identical. If, instead of trying to make a diagnosis, the roentgenologist sends the internist a description of the cardiac shadow and states whether or not it is enlarged and denotes the chambers or vessels which show enlargement, he is rendering a service that is based on sound scientific principles, and one that should be deeply appreciated by the physician receiving the report.

SUMMARY

1. The cardiothoracic ratio offers an easy and accurate method of determining cardiac enlargement.

2. The demonstration of a small heart is often as helpful as the demonstration of a large one.

3. Diseases of the myocardium, endocardium, pericardium, great vessels and kidneys produce cardiac shadows of different shapes, some of which may be used as points in differential diagnosis.

I wish to express my deep appreciation of the assistance rendered me by Dr. Geo. W. Holmes, Dr. William H. Smith and Dr. Paul White. Without their aid and instruction the preparation of this paper would have been impossible.

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AN ANALYSIS OF ELEVEN HUNDRED ROENTGEN EXAMINATIONS OF THE GASTRO-INTESTINAL TRACT*

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Charlotte Sanatorium

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IN making an analytical study of the symptoms and roentgen findings in a series of cases, there is much additional information that one would seek if it were possible again to marshall the host before him. He would note the previous operations very carefully. He would pin the patient down to some definite, outstanding symptom, instead of accepting the vague replies that are made, as "indigestion," "gas," "general discomfort," etc. So we find in reviewing our cases that there are many points we would like to know. We have tried to work with an open mind, inquiring into these points after our diagnosis was formed, consequently some points were necessarily overlooked.

In this series we try to note the principal symptom, or at least the symptom that drove the patient to seek medical attention. It has been difficult to follow the cases because the work was done in different hospitals, and often the patients came from doctors and surgeons in distant towns and returned to them for treatment; so the operative and clinical findings were not always secured.

There were two conditions that led to this study. First, the frequency of the epigastric pain as a presenting symptom, often resulting from pylorospasm, due to appendix or some other exciting cause. Second, the frequency of the occurrence of chest pathology in the cases presenting gastric troubles. When the study was almost finished I was pleased to hear a paper by Drs. Christie and Groover[1] on this latter subject at a meeting of The American Roentgen Ray Society.

This series of gastro-intestinal cases numbered eleven hundred, and showed the proportion between male and female to be almost equal, women 516, men 584.

*Thesis presented with application for membership in The American Roentgen Ray Society.

TABLE I

PRESENTING SYMPTOMS

Vague digestive and nervousness	390
Epigastric pain	207
Right side pain	180
General abdominal discomfort	139
Gas	66
Biliousness and vomiting	36
Headache and nausea	14
Diarrhea	12
Difficulty in swallowing	11
Abdominal mass	9
Constipation	8
Pain in left side	7
Jaundice	4
Anemia	4
Cerebral symptoms	2
Urticaria	2
Obstruction	2
Vomiting blood	2
Epilepsy	1
Paralysis agitans	1
Rectal pain	1
Loss of weight	1
General arthritis	1
	1100

In the series the largest number, 390, came complaining of general indigestion, or indigestion and nervousness and malaise. They are classed in the table as "Vague Digestive". The next in frequency was 207 epigastric pain. These cases varied from intense hunger pain to the vague discomfort, and include those subjective symptoms upon which the clinician usually bases his diagnosis of ulcer.

Following this, we find right side pain with 180 cases. I have not attempted to classify this symptom. It includes the pain, front and back, high and low, on the right side, and the number seemed sufficient to demand attention. Of the physician's *bête noir*, left side pain, I note only seven cases.

Next we notice a symptom that is really rather common, general abdominal discomfort, with 139 cases. This, like indigestion, covers a multitude of sins, varying everywhere from a fullness to a diffuse, general pain, a complaint which is even more common than this number would indicate. While in this series there are only ten or fifteen colored patients, we might say that one rarely sees a patient of this race from whom this symptom cannot be elicited.

Following this come 66 cases with a group of symptoms that the general practitioner meets frequently. The patients give a list of symptoms generally starting with "gas," "sour stomach," "heart burn," "belching," etc., and if they are "fair, fat and forty" the clinician thinks of some gallbladder trouble.

The next 36 cases present symptoms that also sound familiar—frequent bilious attacks with vomiting of bile and often nervousness and sick headache.

The other symptoms shown in Table 1 need no discussion since they represent a rather large variety and very few are of special interest.

Now in regard to the roentgen findings, since some cases present two or more pathologic conditions which are difficult to tabulate, but where a certain condition is the most noticeable, this is chosen. There are only 107 cases reported as negative, but if the list were culled carefully other cases would fall under this head, since findings were reported other than those which pertain to the gastro-intestinal lesions.

While the most frequent diagnosis made is the appendix, and while I am fully convinced that it does influence the digestive tract, the writer agrees with Pfahler[2] and others in regard to this much maligned organ, and believes that if the patient with a barium meal is constantly watched, at some hour during its passage the organ can generally be demonstrated. But here I have classed as chronic 117 of the 301 cases, these being the cases that showed adhesions, tenderness or constriction, or that retain barium some time after the cecum is emptied. The 141 that are reported as simply patulous, while they were not pathological were conceded to be potentially so. Furthermore, those combined with stasis and ulcer were most probably of the chronic type. It is interesting to note that 33 per cent of duodenal ulcer cases were accompanied by a patulous and chronic appendix. Attention of the gastro-enterologist and surgeon was called to this and in many cases a pathological appendix was found. Certainly the occurrence is frequent enough to suggest to us the plausi-

bility of a theory as to the cause of duodenal ulcer, viz., that the chronic appendix reflexly causes a pylorospasm or duodenospasm, and that this is followed or accompanied by a hyperacidity, possibly causing or contributing to an erosion which gives a seat for the invading organism.

Of the class of cases, numbering 46, diagnosed as dilated duodenum, which showed as a rule the symptoms outlined by Vanderhoof[3]—nausea and vomiting, bilious attacks, headaches and nervousness—many were due to extreme ptosis of the stomach, some to adhesions, and one or two were accompanied by lordosis. Only one was of the extreme type referred to by Engelbach[4] and I believe only one came to operation.

In regard to chest conditions, although they are amply sufficient to demand consideration, we do not have quite as large a percentage as in the series of Christie and Groover.[1] This is possibly due to the fact that only in the cases in which routine fluoroscopic observation seemed to indicate did we make a plate for careful study. The lungs showed pathology in 47 cases and the heart and aorta in 29 cases, giving a little over 7 per cent in which the chest pathology was at fault. This does not include many cases in which there was pathology here and a frank lesion in the alimentary tract, but only those cases in which this condition was the principal lesion observed.

In our laboratory it is almost a routine to examine the teeth, certainly any suspicious ones. And in these thirty-one cases, while the rest of the alimentary tract was negative, they were considered sufficiently bad to suggest that they might be causing some trouble.

In regard to the liver and gallbladder region, the pathology was located here in 110 cases; 35 of these carried a report that we dislike to give—"suspicious gallbladder," but since evidence was not conclusive this term was used. I am unable to say how many of the 22 reported as gallstones were confirmed by operation, certainly the majority.

The frequency of cancer in this series has been striking, but this I believe is explained by the fact that our clientele comes from a large area of country, and that, as is well known, these cases go to specialists only as a last resort.

TABLE II

ROENTGEN FINDINGS

Negative		107
Appendix		301
with ulcer	21	
with stasis	22	
chronic	117	
patulous	141–301	
Stasis colon		79
Stasis small intestine		4
Spastic constipation		53
Duodenal ulcer		28
Gastric ulcer		28
Pylorospasm		18
Dilated duodenum		46
Gallstones		22
Suspicious gallbladder		35
Cholecystitis gallbladder		39
Kidney stones		9
Cancer		55
Gastric	32	
Colon	7	
Rectum	2	
Gallbladder and liver	9	
Esophagus	4	
Pancreas	1—55	
Cardiospasm		6
Diverticulum of esophagus		1
Dilated heart and aorta		29
Pulmonary tuberculosis		47
Bad teeth		31
Intestinal obstruction		2
Pyloric stenosis		2
Colitis		31
Gastritis		2
Duodenitis		2
Incompetent ileocecal		13
Ulcer rectum		3
Adhesion ileocecal		23
Abscess sub-diaphragm		2
Abscess liver (amebic)		1
Abscess pelvis		1
Abscess spleen		1
Ptosis stomach		20
Ptosis colon		7
Ptosis intestines		9
Ptosis kidney		6
Syphilis stomach		9
Syphilis liver		2
Pelvis tumor		1
Hernia with adhesions		3
Hyperthyroid		7
Redundant colon		2
		1100

Under the head of pylorospasm, used here in the sense of irritable or spastic, there are only 18 cases. There is always a cause for this condition but these represent the cases in which no cause was located. My observation has been that it generally manifests itself in epigastric pain, which brings me to the study of the 207 cases presenting this symptom. (See Table III.)

TABLE III

EPIGASTRIC PAIN

Chronic appendix	75
Duodenal ulcer	44
Gastric ulcer	18
Pylorospasm	14
Duodenal ulcer and appendix	15
Gastric carcinoma	7
Gallbladder with pylorospasm	6
Kidney stones with spasm	5
Cecal adhesions	5
Spastic constipation	5
Bad teeth and spasm	4
Negative	4
Dilated aorta	2
Duodenitis	2
Dilated duodenum	1
	207

Of the findings in these cases the ulcer cases, carcinoma, and possibly the cases of duodenitis, or about 86 cases, would cover those having sufficient lesion to explain the pain. In the remaining 121, the pain must have been due to pylorospasm; in all but 14 there was some cause found, and I feel that if a closer study could have been made in the cases marked "Pylorospasm" alone, the cause might have been determined. It is striking to observe how many cases of chronic appendix were observed here, also the frequency of the location of the lesion elsewhere, as kidney, gallbladder, and colon.

There are many other interesting points that have arisen in the study of these cases, but it is not necessary to mention them at this time.

I wish to thank Dr. W. O. Nisbet and my other associates for their assistance in working up these cases.

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CONGENITAL ATRESIA OF THE ESOPHAGUS*

By E. H. SKINNER, M.D.

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THE rarity of case reports upon congenital atresia of the esophagus in roentgen literature prompts a report of the following case seen in consulation with Dr. Frank C. Neff, of Kansas City.

In this condition the upper third of the esophagus usually ends in a blind cul-de-sac which is often dilated (Adami, Page 397). The lower part may be absent completely, or the lower portion forms a fistulous opening into the trachea or bronchus. The embryological explanation of these cases is lacking. Cautley classifies malformation of the esophagus into eight general divisions. His article is quite expansive and it should be consulted by anyone interested in following up this kind of case.

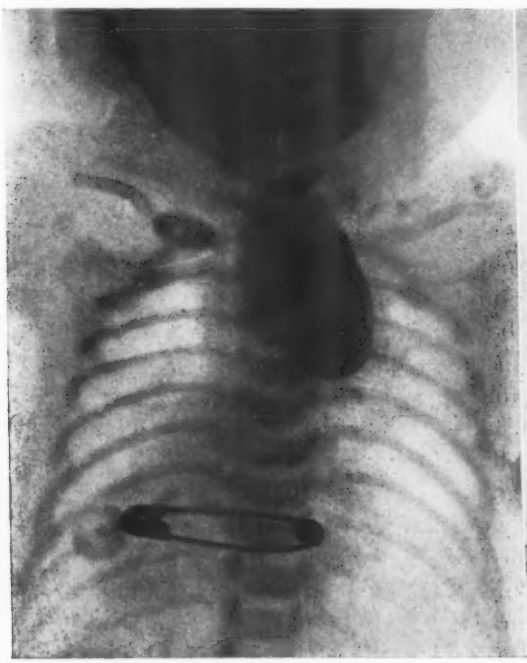

FIG. 1. Antero-posterior projection showing complete obstruction of the esophagus above the atresia with dilatation.

Fig. 2. Oblique projection showing the same condition.

CASE REPORT

Baby V. H., girl, born October 25, 1920, weight six and one-half pounds. Four brothers living and well; one sister dead, cause not known. Parents well. This child was two weeks premature, but delivery was normal. Vomited all the milk immediately after each breast nursing.

This baby was seen in consultation upon the fourth day of life and appeared to be well nourished, with a grunting respiration and normal temperature, no pyloric tumor, no peristaltic wave, and with a history of having vomited every nursing, although the child appeared to be hungry and nursed eagerly.

The little patient was brought to the laboratory sandwiched between two hot water bottles. Barium was mixed into breast milk in a nursing bottle. The baby eagerly nursed this from the bottle. The fluoroscopic examination showed a cul-de-sac formation reaching just below the clavicle to the level of the fourth dorsal vertebra. It was of a character and size frequently seen in adults suffering with a Zenker's diverticulum. The lower

*Read at the Second Annual Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY, St. Louis, Mo., Feb. 21, 1921.

margin of this pouch was smooth and rounded with absolutely no evidence of any canalization of the lower two-thirds of the esophagus As soon as the cul-de-sac was filled with the barium suspension the child began to vomit but did not relieve the cul-de-sac entirely.

The attached illustrations were taken in the dorsal position of the patient and in the antero-posterior and lateral planes. They represent quite exactly the size and outline observed with the fluoroscope.

The subsequent history of the case is brief. Inasmuch as inanition was imminent and complete obstruction apparent, a gastrostomy was performed the following day and the baby lived forty-eight hours following the operation, during which time two teaspoonfuls of breast milk and warm water were fed through the fistulous opening into the stomach every hour.

The autopsy revealed that the esophagus ran down to the level of the bifurcation and ended in the form of a pouch with a fibrous band attaching it to the trachea. Extending up from the cardiac end of the stomach was the lower portion of the esophagus with a patent lumen for about 2 cm. At this point it disappeared, becoming fused with the mediastinal tissue. The stomach was small but of normal development.

This case corresponds with type 7 (b) as classified by Cautley.

There have been two case reports of the atresia of the esophagus in American pediatric journals, which also carry roentgen illustrations. These are cited in the following bibliography.

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DISCUSSION

Dr. A. W. Crane. Some years ago we had a case of atresia of the esophagus which was exactly the same as the case just reported. After the baby's death we brought the body to the office and did a postmortem. We injected a barium mixture into the stomach through the pylorus. This mixture filled the esophagus from below, and when *x*-ray plates were made, an anastomosis of the lower esophagus with the trachea became apparent.

There have been quite a number of cases reported at the Chicago clinics. In all of these, so far as we have records, a communication between the lower portion of the esophagus and the respiratory apparatus was found. Death would of course invariably result in all of these cases.

Dr. L. T. LeWald. We had a case of this sort in which demonstration was made by a catheter passed into the esophagus, and then an *x*-ray exposure was made which showed the point of obstruction.

In all the cases of this sort observed at the New York Lying-in Hospital there was a communication between the lower portion of the esophagus and the respiratory tract.

I would like to ask Dr. Skinner if there was any communication in his case?

I know of four or five cases which have been operated upon unsuccessfully because the communication between the stomach and the respiratory tract was not recognized. The surgeon should close the cardiac end of the stomach in addition to performing a gastrostomy.

Dr. E. H. Skinner. Replying to Dr. LeWald; there was no trachea-esophageal fistula in this case. Such types are, however, more frequently encountered.

X-RAY WORK FROM THE VIEWPOINT OF AN INTERNIST

By GEORGE DOCK, M.D.

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I CANNOT appear before this body without thanking your President for the honor conferred on me by the invitation. Coming from him, it seemed a command as well as an invitation, for I am under an old debt of gratitude to him for his keen and enthusiastic cooperation in my clinic before he took up the work to which he has since devoted himself with great success.

I have other reasons for appreciating the invitation to address your meeting. I have had a long-standing interest in *x*-ray work and have been in almost daily contact with roentgenologists since I was initiated into the possibilities by such masters as Crane, Hickey and Hulst. Nor can I forget that cheerful co-laborer, Vernon Willey, whose death cut short so much promise. Later I had the association of the genial Granger in New Orleans, and of Russell Carman and Walter Mills here. I began with the crude fluoroscopy of the earliest days, guided by technicians skilled only in electricity and photography, but soon I realized the great extent and seriousness of the subject and was glad to depend upon experts with whom I have long worked intimately, combining thus the clinical and radiological points of view.

I shall speak chiefly from the clinical standpoint, but as one who finds radiology as indispensable as percussion or the microscope, and demanding the same devotion to make it a success. This leads to some consideration of specialists, concerning whom so much has been said, and so much that is contradictory. The contradictions have often been due to the differences in specialists and specialties, and those relating to roentgenologists will be repeated in the case of many other technical methods in future as they have in the past.

Novelties in medical diagnosis are taken up and cultivated by people of all ages and degrees of experience or inexperience. If the work is of a kind requiring not only skill, but also complex, costly and rapidly changing apparatus, it cannot be taken over generally as can simpler methods. We can compare physical diagnosis or urinary microscopy and the simple urine chemistry on the one hand with serology, radiology and blood chemistry on the other. The work then forms not a medical specialty, like ophthalmology or internal medicine, but a technical specialty. If the one who cultivates it has little or no medical training he remains a technician unless by a combination of mental gifts, opportunity and hard work he acquires the other necessary knowledge. The more widely experienced man who cultivates a new technical method, acquires the physical equipment and uses it along with his other methods, becomes of course a broader and more efficient man than he was before, a higher type of specialist. If he chooses to hand over the more mechanical part of the work to an assistant or servant, he is still at an advantage over those who have all that he has except the finished technical knowledge, just as he also has an advantage over the technician, no matter how much of a virtuoso the latter may be. If such a man as I have described has a fairly large amount of work, if he does original investigating, keeps up with the literature of the subject, attends special meetings, visits other laboratories, imparts his knowledge to others through addresses, articles and books, he occupies just as important a position as any specialist and will have the same sort of recognition. At another end of one class we find a specialist who cultivates roentgenology only as an aid to his clinical work—the tuberculosis specialist, gastro-enterologist, etc., whose work will be legitimate if it is good.

As in other lines of medicine the difference in the ability of roentgenologists is not

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known by the public, or even by all physicians in their spheres of activity. So we see men asked to make diagnoses or to do operations for which they are not fitted; to refuse to act is sometimes more than human nature can stand, but consent is fraught with danger to patient and reputation. Not even organizations such as special societies or national "colleges" can stop this, nor probably anything else except greater enlightenment and publicity regarding medical work.

There is room in every city of considerable size for roentgenologists of the highest type. Other specialists will be glad to obtain their services in many cases. Family physicians and general practitioners must constantly call on them for assistance. But many such specialists will suffer from the necessity of covering too large a field ever to become preeminent in any one department, such as bone, chest or gastro-intestinal work. It will probably be best for the roentgenologic specialist to specialize still more, and it would be well, where there is more than one in a city, for each to restrict his work to the line or lines in which he is most skilled. In this, as in so many other aspects of medical life, cooperation offers the most desirable conditions for work, and a group of roentgenologists might also be part of a larger and more varied group of specialists, until they form the most complete team.

Roentgenology furnishes an interesting light on changing conditions in medical economy. Formerly hospitals and medical scools were the nurseries for new and developing technical methods and technicians, but both these kinds of institutions are likely to have restricted budgets, and it is often impossible for them to furnish the few or many thousand dollars necessary to equip and conduct such a thing as an *x*-ray department or a radium supply, just as it is impossible to equip and conduct a chemical laboratory or modern bacteriological laboratory or heart station. Those who work in universities, as a rule, have no private capital for such purposes, and so the demands can usually be met only by specialists with large practices, or by groups of specialists with initiative as well as credit.

Leaving this rather material but essential phase of the subject, let me consider another. An important fact about medical diagnosis, often overlooked, found in *x*-ray as it is in other kinds of work, is that positive findings are, as a rule, of limited application, and must be combined with others to give them clinical value. It has taken a long time for physicians to recognize these truths, and many do not bear them in mind even now. For centuries there was a search for pathognomonic signs, and these were but slowly relegated to a subordinate place as their lack of certainty was demonstrated; but each new method still revives the same sort of hope. Dozens of methods of percussion have been devised, and hundreds of stethoscopes invented, with the hope that each one would give unequivocal results. Hundreds of men worked at urea determinations believing that if they could only get the right method they would end all trouble in the diagnosis of protein metabolic errors, gout rheumatism and what not. Men have deluded themselves into searching for cancer cells, for cells characteristic of limited areas, such as the ureters and the renal pelvis. Even now, although the fallacy has been known for years, men will titrate for hydrochloric acid in stomach contents, solely to recognize or exclude cancer of that organ, and for some years many will think that a basal metabolism determination will save all the minute examinations of a large and varied clinical material. In roentgenology, many had an idea in the beginning that with its aid one could do for a gastric ulcer or tumor what the gastroscope had failed to do—make it it visible as certainly as the ophthalmoscope makes retinal hemorrhage or a choroiditis visible.

The truth is that discoveries in diagnosis do not shorten or make easier the work of diagnosis. They make it more accurate, they make it fuller, but only by enlarging the manual work of the diagnostician and calling for a greater capacity for generalizing. The

same sort of disappointment followed the finding of tubercle bacilli that so often follows the fluoroscopy or skiagraphy of the thorax in certain cases. In each case one hoped that the tedious task of history-taking, physical examination and repeated physical examination and of laboratory tests would be avoided. The dream was, and still is, to endeavor to detect and treat the disease, instead of treating the patient. Very slowly do the real facts appear, and these have different values for each method of manipulation. So the finding of tubercle bacilli in the sputum is positive evidence of tuberculosis, but where, how much, in what form or stage, how virulent and all the rest of the patient's condition, must be worked out by other methods. The finding of elastic tissue in sputum was once expected to do what it was later hoped tubercle bacilli would do—shorten the task of diagnosis. It was long since abandoned for that purpose, and is not used now as much as it should be, for it is easy to find when present, and when found gives proof of a fact that cannot be demonstrated as certainly in any other way, including the use of *x*-rays, viz., the breaking down of the lung, or cavity-formation. But here too the situation and extent of the breaking down must be worked out by other methods, including roentgenologic ones.

Here I may be allowed to comment on some of the features of lung diagnosis with reference to *x*-ray work. The application of *x*-rays to lung pathology was no greater innovation in its time than the use of percussion and auscultation a century earlier. Both the latter became useful very soon after they were applied, because they had been tested by the results of other clinical methods and of postmortem examination by their discoverers and others. Not only what they could reveal, but what they could not reveal, were made clear within a short time of their application. Only details were added later, and these depended upon other new technical methods, or upon additions to pathologic anatomy and etiology.

Roentgenographic methods as applied to the lungs do not differ essentially from auscultation and percussion. All depend largely on differences in density of the structures concerned, and on physical facts relating to density. There is another similarity. Auscultation and percussion are strongly personal methods, affected by the special senses, tact and technical skill and by experience and accurate thinking on the part of the examiner. I think that in roentgenology the same qualities are all necessary, with the additional drawbacks of the freaks of machinery and electric currents, of screens, plates and reagents. The same things that affect auscultation and percussion in the body of the patient—thickness of chest wall, size of thorax—affect the fluoroscopic picture and the skiagram. I think it is a fact that *x*-ray work on the lungs was not controlled by anatomic investigation to the same degree that auscultation and percussion were. This was due partly to a general decline in postmortem examinations that seems to be getting worse instead of better, and further due to conditions too complicated to consider in detail at this time. But it depended also, I think, very largely on the fact that many *x*-ray specialists had little knowledge of lung diseases, and especially had no familiarity with either the gross or microscopic conditions in lung diseases. Yet on account of the striking results of *x*-ray examinations of bones, early roentgenologists were forced into the position of lung diagnosticians with extraordinary powers.

The sources of difficulty in roentgenologic examinations of the lungs did not, in the beginning, and do not now seem to be recognized as accurately as they should have been and should be. For example, with percussion it was easily shown that in order to alter the percussion sound, a lesion must reach a certain size and lie within a certain distance from the chest wall, and with recognizable sources of confusion in the chest wall itself. With *x*-ray work many technicians assumed from the beginning that all lesions could be made out in the screen or plate, and boldly made diagnoses of things they had never seen before. In the beginning inferior screens and imperfect technique

were unavoidable. With inferior technique the *x*-ray plate gave a set of silhouettes of planes showing areas of varying density superimposed on each other. With better technique, including the stereoscope, it gave an infinite number of perspective views superimposed. In both cases something between one third and one half of the field were obscured by those dense structures, the ribs and heart. Yet in spite of these difficulties much excellent work was done—much work of very great value clinically—and for this result the small number of close students of anatomic and *x*-ray examinations and a comparatively small number of talented and cautious technicians must be thanked.

X-ray methods should be applied much more freely to the study of lung diseases than they are now, not only for the certain additions they will make to knowledge, but for their practical value. They can confirm many points disclosed—but not fully enough—by auscultation and percussion. They make clear in certain cases that what had been a bronchitis is really a pneumonia or some other process affecting the air cells or the blood vessels, lymphatics or interstitial tissue of the lungs. They can reveal a process that was often suspected on using older methods, but could not be proved by them, such as an infiltration of an inner edge of a lung, or an effusion between lobes not reaching the surface to an extent permitting recognition by percussion.

They have shown the not infrequent existence of small pneumothorax cavities in various parts of the thorax. This may not be as important a finding as some others, but adds much to our knowledge of thoracic pathology. But here one may mention an important clinical fact, the kind of fact that cannot be lost sight of in discussing diagnostic technique. Any one with a rather wide observation of *x*-ray reports on thoracic cases will see some in which even a large pneumothorax is not recognized in the fluoroscopic plate, though it may be by physical signs, and on the other hand, cases are said to have pneumothorax when further *x*-ray and other examinations show nothing more than an artefact.

Another condition not yet investigated by roentgenologists as much as it deserves, is atelectasis, including the interesting form described as massive collapse of the lungs (W. Pasteur and others).

Physical diagnosticians always lay stress on repeated examinations, having learned that a single one is likely to be incomplete. In striking contrast to this is the confidence with which many *x*-ray specialists will make a positive diagnosis from a single examination and sometimes a prognosis. Even more, patients are ordered to Arizona or California upon the finding of an enlarged hilus shadow or of density in the apex, without further inquiry.

Physical diagnosis is notoriously beset by the perils of a strong personal equation, and physical diagnosticians are rightly expected, by those who seek their help, to explain on what grounds they base their conclusions. The personal equation in the interpretation of *x*-ray findings is present too, though perhaps not to so great an extent; and yet we find *x*-ray specialists who refuse to show plates to physicians consulting them, but hand out ex-cathedra diagnoses from which there is no appeal. I admit this is rather uncommon, but that it exists imposes upon the specialty the task of reforming its practitioners.

The *x*-ray specialist is at a serious disadvantage in the matter of following up cases. In physical diagnosis we learn much, in cases not coming to autopsy, from the sequence of events. But the *x*-ray operator can only do this with inconvenience to the patient—sometimes impossible to overcome—and expense to someone. This matter of expense is one of the most potent causes of the backward condition of thoracic *x*-ray work. If *x*-ray plates were as easy to get as temperature charts how rapidly could we enlarge the comparison of *x*-ray and anatomic results, as shown by the valuable serial study of influenza-pneumonia by Sante! But the cost of material and the time of technicians pro-

hibits this work almost wholly. The difficulty of financing such essential work, in contrast with the ease of financing measures for destroying life, is one of the most depressing phenomena of the time we live in.

Among unscientific practices in *x*-ray work on the chest may be mentioned the unfounded confidence on the part of many in the interpretation of shadows of the hilus region. All who have had postmortem experience know how often the glands in the roots of the lungs become enlarged. They become so by congestion and edema in many cases of bronchitis and bronchopneumonia; they become so on account of tubercles, many of which heal, leaving calcified or fibrous areas very often; they become so on account of various causes of irritation, many of which leave no other evidences of danger than the enlarged shadows. I have often been told of cases or have seen reports in which such enlargements were given an exact etiologic name; viz., tuberculosis, but I have never had demonstrated the grounds on which the diagnosis had been made, except as regards calcification.

Pathological-anatomists are also familiar with many cases in which there are areas of disease of varying sizes, from those barely visible to the naked eye up to the size of hempseed, that cannot be differentiated by the naked eye, and under the microscope cause much difficulty. These are especially bacillary tubercles, gummas, miliary carcinomas and lymphomas, but sometimes actinomycotic granulations or other processes. All of these and some other dense areas that I cannot explain are likely to be called miliary tubercles if they show on the screen or plate. It is not less surprising to see the confidence in the diagnoses than the belief that the diagnosis of miliary tuberculosis, without further qualification, is of any great value.

Anatomists know that miliary tubercles may occur in very small numbers, so that they might be visible singly on the plate. But these are often of slight clinical value. They occur in that form either as terminal lesions in fatal cases, or heal without having been suspected during life. Clinically, miliary tuberculosis of the lungs is well known, though not always easy to recognize. In the great proportion of cases in which I have known the *x*-ray diagnosis to be made, it has not been borne out by the further course of the disease, if favorable, or the autopsy, if fatal, and in many cases fairly extensive tuberculosis has been present without being suspected by the radiologist.

Larger areas of density in the lungs are also frequently asserted to be tuberculous, but I am not aware of any criteria by which one can distinguish between, let us say, catarrhal lobular pneumonia in influenza or other conditions, tuberculous bronchopneumonia, and other similar focal processes. A fact familiar to all clinicians who utilize *x*-ray work, but too often overlooked by technicians is that very often pin-head or hempseed sized lesions are shown on the plate, but larger ones may be missed, even up to those that give physical signs. It is interesting to see that the *x*-ray diagnosis of cavity is still missed in both senses—diagnosed when not present, overlooked when present in considerable volume.

A common mistake made by *x*-ray operators is often made also by physical diagnosticians. There is some excuse for it, as the mistake was once made by Laënnec himself, but it should be avoided by a habit of caution. The situation is as follows: A patient known to be tuberculous, or found to have a suggestive history and signs of a lesion in one apex or both, shows signs of a bronchopneumonic process in one or both of the lower lobes, or even more. The *x*-ray plate, like the auscultation, shows a widespread bronchopneumonia. It is assumed to be a peribronchial tuberculosis or bronchopneumonia and a bad prognosis is given on account of the wide extent, but it may be a simple coccus inflammation of mild virulence and may rapidly clear up, with much adverse comment on the part of those who observe the obvious mistake.

This reminds me of the frequent note "active" in connection with a diagnosis of tuberculosis by *x*-ray specialists. I have never

had anyone demonstrate the reason for such a diagnosis when based on a single examination. One can say that a calcified area, on the other hand, is evidence of an old lesion. Most probably it is inactive, yet it may liberate viable bacilli at some time and become active. The work of Opie on calcification in the lungs and other organs should be carefully studied by radiologists, not merely for the technical bearings, but even more on account of their relation to prognosis.

I also view with scepticism the *x*-ray diagnosis of tuberculosis of an apex, since the only tuberculous lesion likely to agree with the diagnosis is an obsolete one, in which no one can predict renewed activity. Auscultation, I think, is much more trustworthy in apex lesions, though the skiagram should always be made, preserved and compared with later ones. The methods of apical roentgenology offer a striking contrast to those followed in gastric, duodenal and gallbladder work.

X-ray examinations are indispensable in the accurate recognition of all chronic diseases of the lung and pleura, and especially bronchiectasis and encysted old pleurisies with or without fibrosis, but without the exploring needle the latter cannot be understood. In these two conditions *x*-ray specialists can learn much from thoracic surgery, and it is to be hoped that all cases suitable be carefully studied before, at, and after operations on lungs and pleurae.

Roentgenology is indispensable in the diagnosis of aneurysms, for some can only be recognized in this way and even those made out by the physical signs can be more completely explained by *x*-ray examinations. Yet even in this field there are sources of error that the mere technician will do well to bear in mind. The heart and pericardium furnish another field deserving careful collaboration between roentgenologists and anatomists. I have seen one of the former make the same mistake that sometimes befalls the physical diagnostician—take a pericardial effusion for enlarged heart, because the cardiohepatic angle was not obliterated, as it is supposed to be with effusion, but is not always.

The great field of dental radiography furnishes many illustrations of the fact that it is still in the stage of development. Experts are too prone to give positive statements of films or plates alone, sometimes missing quite important lesions, then again ordering removal of teeth, a problem purely dental.

Some old errors are certain to be repeated in the interesting field of pneumoperitoneal fluoroscopy and skiagraphy. One can make out organs beautifully; one can detect many small foci of disease on the surface, but histologic features will not be cleared up, so the need of exploration cannot be avoided. The same sorts of mistakes that have been made through relying on examinations of ascitic fluids will be made in this variety of roentgenologic work, if it is depended upon alone.

The great advances in gastro-intestinal fluoroscopy and skiagraphy, intestinal ulcerations and adhesions, and especially diseases of the stomach and duodenum, bile tract and appendix, throw a flood of light on the methods of improving all departments. I have spoken of the need for autopsies in clearing up lung diagnosis. In gastro-intestinal work we have the invaluable cooperation of the surgeon in very many cases, so we owe him, as well as the physiologists who have added so much to the subject, thanks for a great part of the advance, and we should keep in close touch with all operative procedures on *"geröntgt"* patients, in order to have a vivid picture of actual conditions.

Your President has asked me what undergraduates should be taught about *x*-ray work. That is a large and very important question. I will simply tell what we do here without wishing to be understood that we think we have reached finality either in methods or results.

Our students are given demonstrations in the anatomical course showing the use of *x*-rays in embryology, bone development and evidence of age in growing bones. It is used

by Dr. Opie in the teaching of pathology. I take the class in the second third of the second year, with a course in physical diagnosis, and use selected plates to show types, especially of the thorax, variations of position of thoracic organs in health and disease; position of stomach and intestines. As the members of the class percuss and auscult each other, and make diagrams of the results, we select a group of various shapes of heart dullness, and various heights of diaphragm, mark out the percussion lines with lead strips and take seven foot plates in the same quiet breathing in which percussion was done. These are placed before the class in the following exercises. If we find anything abnormal in these healthy subjects, such as signs of old pleurisy, valvular lesions, etc. we get plates and demonstrate in the same way. We do not allow the class to use the fluoroscope on account of the number (thirty-five) and the risk of prolonged exposure from overenthusiasm or of waste of time from too brief observations. In this same class we show the skiagrams of patients who have been seen and palpated for pleural friction, thrills or aneurysmal pulsations, of those who have been demonstrated with dullness from pleural effusion, then tapped, with plates taken before and after, and demonstrations of the resonance in the cleared area.

In the third and fourth years we study with the class or groups all the plates of patients seen in out-patient department and wards. Students spend three months each year in each division of Medicine, Surgery and Gynecology-Obstetrics-Pediatrics, see plates of many of the cases under their care, and have an opportunity of seeing fluoroscopic examinations of many lesions such as esophageal stricture, cardiospasm, gastric and duodenal ulcer, gastric carcinoma, colon diseases, including diverticulosis. I should add that we take tuberculosis patients in all stages (in limited numbers) and are able to study the *x*-ray features as thoroughly as possible.

My colleague, Mills, gives a series of demonstrations of diagnostic work in abdominal disease, and he, as well as Dr. Sherwood Moore, offer optional courses in *x*-ray diagnosis and technique.

In other departments equal importance is given to the study of plates and fluoroscopy, the bone and cranial work occupying a very large field.

No practical work with tubes is given, except to individuals with spare time and sufficient preliminary training, or in special courses.

We consider knowledge of *x*-ray evidences of disease essential to the graduate, but think technique and original diagnostic work should be taken up by a course of apprenticeship later on, though it may begin in the interne year. In other words, we think every student must know how to use a laryngoscope and ophthalmoscope, to know the elements of bacteriology and serology, but that not everyone as an undergraduate can learn how to use *x*-rays, or for that matter cystoscopes, bronchoscopes, Wassermann technique and many other matters.

As many of you heard the outline of graduate education by Dr. Louis B. Wilson at the September meeting of the society, and all have probably read it in the December number of the Journal, I need do no more than express my admiration for the course proposed and congratulate those able to follow it.

THE INTENSITY OF SCATTERED X-RAYS IN RADIOGRAPHY*

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ROCHESTER, NEW YORK

SCATTERED radiation is the only type of secondary *x*-rays which is an appreciable factor in medical radiography. The fluorescent or characteristic radiation from the chemical elements of low atomic weight, such as make up the human body, is negligible. Even the fluorescent radiation from most metals when exited by primary rays of the usual radiographic quality (corresponding to a 5 inch spark-gap) is so soft and of such low intensity that it does not noticeably affect a film through the ordinary cardboard holder or paper envelope.

Most of our information about scattered *x*-rays is from the investigations of Crowther, Barkla and his associates, and Hull. In the study of the fundamental laws of the scattering of *x*-rays, their experiments were performed with relatively thin sections of matter, in order to minimize such effects as absorption and re-scattering of the scattered rays. The principal conclusions reached by these investigators on the scattering of *x*-rays by the lighter elements may be summarized as follows:

1. The scattered radiation from an element is independent of its physical state and its chemical combination.

2. All wave-lengths of *x*-rays (within the the range usually employed) are scattered equally; in other words, the hardness of the scattered rays is equal to that of the primary beam.

3. All substances of the class considered scatter *x*-rays equally mass for mass.

4. The scattering is greater in the direction of propagation of the primary beam than in the opposite direction, and it is greater in either of these directions than in directions at right angles to the primary rays.

In the light of these facts, the best advice has been to use diaphragms to reduce the scattered radiation in radiography, the usual procedure being to limit the volume of matter rayed by means of a cone or diaphragm between the tube and the scattering material.

There has been practically no systematic investigation of the behavior of scattered *x*-rays in large volumes of matter. On account of the considerable effect of scattered radiation in reducing contrast and obliterating detail in the radiographs of thick parts, the present investigation was undertaken to study the scattering of *x*-rays from the standpoint of practical radiography. While we may generalize to some extent on the effects of various factors in technique upon scattered radiation, the lack of quantitative data has prevented any effective analysis of the problem. In the present work the problem of scattered radiation has been approached in two ways, first by measurements of the *intensities* of scattered radiation under various conditions, and second by the *effects* of scattered radiation upon contrast and definition in radiographs[1]. The aim has been to determine the relation of the various factors in the radiographic process to scattered radiation; these factors include those under our control, such as tube voltage, filters and diaphragms, as well as those factors which we cannot ordinarily change, such as amount and distribution of the scattering material.

The effects of scattered radiation can be foretold to a considerable extent if we first know the relative amounts of scattered rays and primary focal rays reaching the plate or film. As a rule, we are apt to judge the amount of scattered radiation affecting a radiograph by the contrast. This is not fully justifiable since the contrast depends to a certain extent upon the character of the photographic material used, development

[1]The data on the effects of scattered radiation will be presented in another paper in the near future.

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conditions, etc. A radiograph can be copied in such a way as to obtain a negative of much greater contrast than the original. Obviously this process does not affect the scattered radiation which was incident upon the original radiograph, although it may overcome the loss of contrast produced by the scattered rays. The method used in the present experiments measured the relative photographic intensities of scattered and focal radiations incident upon the film independently of any contrast effects. The term "photographic intensity" refers to the intensity as evaluated by the photographic material used, as distinguished from the value

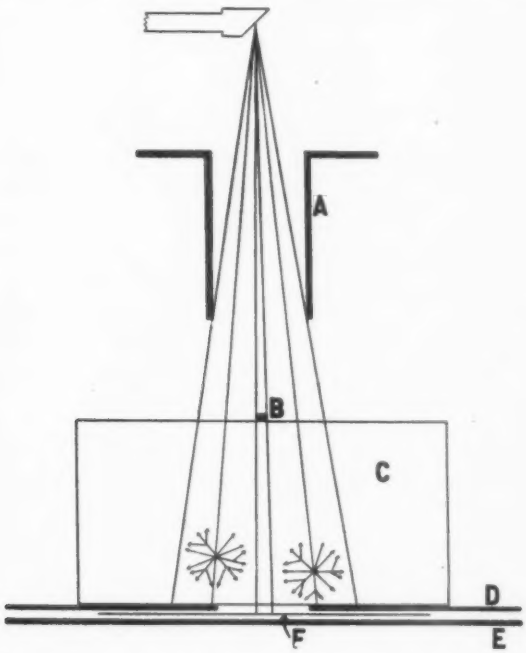

FIG. 1. Diagram showing experimental arrangement for the determination of the ratio of diffuse to total radiation. *A* is a lead cone; *B*, a small lead disk; *C*, the scattering material; *D*, a lead diaphragm between the scattering material and the film; *E*, a sheet of lead beneath the film *F*.

which might be obtained in recording the radiation by some other means, such as an ionization chamber, a fluorescent screen, or a different photographic material. The evaluation of photographic intensity therefore depends upon the way the photographic surface integrates the intensities of the various wave lengths of radiation incident upon it.

The experimental arrangement is illustrated in Figure 1. A thickness of scattering material C was placed over the film F. A lead disk, B, 5/16 inch in diameter by ¼ inch thick, was centered over the scattering material. The only rays which could fall in the shadow of the lead disk were scattered rays and primary rays from other parts of the target than the focal spot. Both types of radiation will be included in the term *diffuse radiation*, while the primary rays coming from the focal spot will be designated as *focal radiation*. The rays falling outside the shadow of the disk included both the primary rays transmitted by the interposed material and the scattered rays.

A lead diaphragm D of 3 inch aperture and 1/16 inch thickness was placed between the scattering material and the film. This enabled six separate exposures to be made from an 8 x 10 inch sheet of film. The area of material rayed could be limited by a cone or diaphragm placed between the tube and the material.

The experimental procedure was as follows: Keeping the tube voltage and current constant, a series of six exposures was made on a sheet of film, producing on development a series of densities varying from light to moderately heavy. Figure 2 shows a series of exposures made in this way. Each exposed portion of the film consisted of a darkened area surrounding a small circular area of lighter density; the density in the small area was caused by diffuse radiation alone, while the density of the outer area was produced by the total radiation transmitted by scattering material. These densities were measured with a photometer, and curves plotted of density against time of exposure, both for the total radiation reaching the film and the diffuse radiation. From these curves were determined the relative exposures required to produce equal densities by the diffuse radiation and by the total radiation; the relative intensity of diffuse and total radiation was taken at the reciprocal of the ratio of exposures required to produce equal density on the film. For in-

stance, if twenty second's exposure to the total radiation produced a given density and twice that exposure, or forty seconds, was required by the diffuse radiation to give the same density, then the diffuse radiation was half the intensity of the total radiation; in other words, half the radiation reaching the film in this case was diffuse, non-image-forming, radiation.

The value obtained is independent of the contrast or degree of development of the photographic material, provided the characteristics of the material are the same for two radiations being compared. In these experiments no definite difference was observed between the characteristic curves produced by the diffuse radiation and the total radiation.

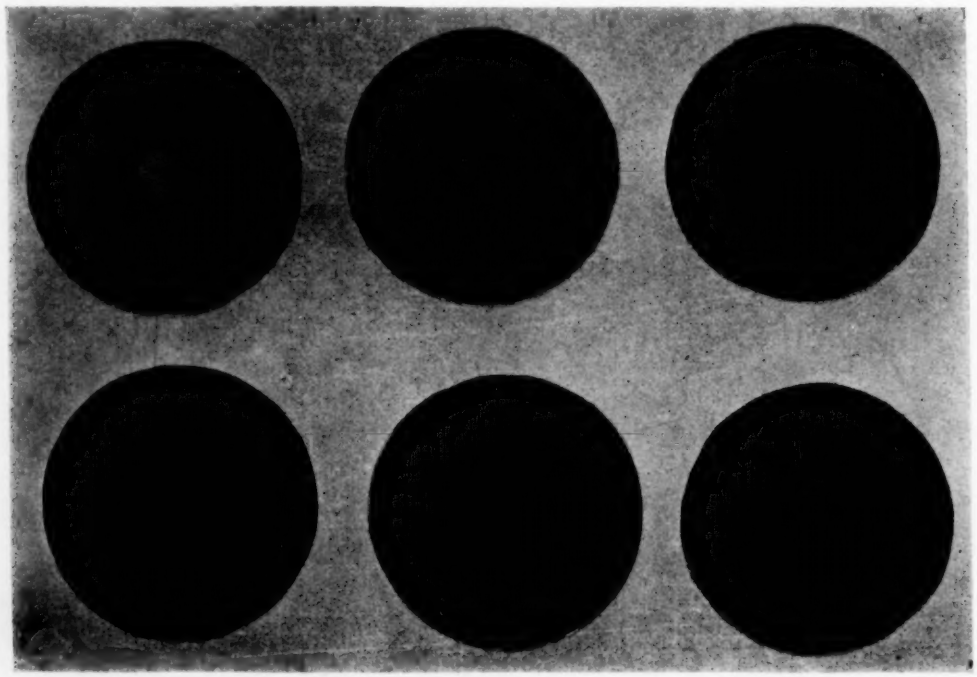

FIG. 2. Illustrating a series of exposures made to determine the ratio of diffuse to total radiation. The lighter density in the center of each exposure was produced by purely diffuse radiation in the shadow of the lead disk; the outer density was produced by the total radiation transmitted by the scattering material.

For most of the work ordinary tap water was used as the scattering material. The density of water and its absorption and scattering characteristics are similar to those of human flesh, making it a very suitable material for the present experiments. The water was contained in an aluminum tank 12 inches square by 10 inches deep. The bottom of the tank was 1/32 inch thick. As will be shown later, the absorption of this thickness of aluminum was too small to affect the results appreciably. Some experiments on scattering were also performed with printer's roller composition, a compound made of organic substances and having a density (ratio of mass to volume) of 1.33. This material is more convenient to handle than water, but its scattering power is somewhat too high to be comparable with human flesh.

The spark-gap was measured between dull points, and the tube voltage kept constant during an exposure with the aid of a voltmeter on the primary of the transformer. The Coolidge radiator type tube was used throughout these experiments. The target-film distance was maintained at 20 inches. The tube current was kept constant during each exposure and was adjusted as far as

possible so that the desired densities could be obtained in exposure times varying from ten seconds upward. For long exposures the tube current was not allowed to exceed 4.5 milliamperes. Duplitized *x*-ray film was used as the photographic material; the films were developed in a tank of elon-hydroquinone developer for five minutes at a temperature approximately 65° Fahrenheit; the films were kept in constant irregular motion to insure uniformity of development[2]. As stated previously, the degree of development of the film has no effect upon the values obtained; the chief consideration is that each film receive uniform development over its whole surface. For each set of conditions six or more films were exposed (unless otherwise specified) and the average value obtained of the ratio of the diffuse to the total radiation reaching the film. The effects of diaphragms, thickness of scattering material, tube-voltage and filters (between the scattering material and film) upon the ratio were investigated.

Figure 3 shows examples of the curves obtained of density plotted against exposure time. The film giving these curves was exposed through six inches of water with the tube running at 5 inch spark-gap and 3.5 milliamperes. The exposures varied from 10 to 40 seconds. The densities of Curve 1 were produced by the total radiation reaching the film, while the densities of Curve 2 were produced by the purely diffuse radiation falling in the shadow of the lead disk. If there were no diffuse radiation, Curve 2 would coincide with the dotted line F representing the fog density, or the density of the unexposed portions of the film. It will be noted, however, that the densities from diffuse radiation are not much less than those produced by the total radiation. At several density values the corresponding exposure times for diffuse and total radiation were read from the curves and their inverse ratios calculated as shown in Table I. The average of these ratios gave the value determined from this film, and the final average was taken from six or more such films. From these particular curves the value of this ratio is .84; in other words under these conditions 84 per cent of the total radiation striking the film is diffuse radiation and 16

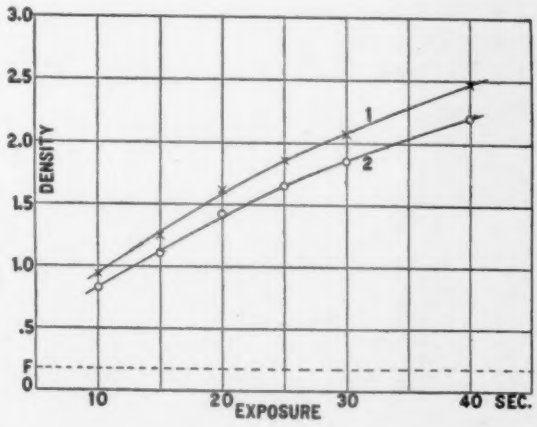

FIG. 3. Curves of density of film plotted against exposure time. Curve 1 is for the total radiation reaching the film, and Curve 2 the diffuse radiation in the shadow of the lead disk. Conditions; 6 inch depth of water (12 x 12 inches) as the scattering material, 20 inch target-film distance, 5 inch spark-gap, 3.5 milliamperes. *F* represents the fog density, or the density of the unexposed portions of the film.

TABLE I

DATA TAKEN FROM CURVES OF FIGURE 3

Density of Film	*Exposure to Total Radiation in Seconds* E_T	*Exposure to Diffuse Radiation in Seconds* E_D	*Ratio of Exposures* $\frac{E_T}{E_D} = \frac{D}{T}$
1.0	10.7	12.8	.84
1.3	15.4	18.2	.85
1.6	20.2	23.9	.84
1.9	25.9	31.3	.83
2.2	33.2	40.4	.82
		Mean	.84

[2]This precaution is unnecessary in developing ordinary radiographs.

per cent is image-forming or focal radiation.[3]

The proportion of diffuse radiation reaching the film was first investigated for various thicknesses of water and different sizes of cones or diaphragms[4] with the tube running at a 5 inch spark-gap. The results are arranged in Table II.

as long as the image diameter on the film is kept the same. Therefore with a constant target-film distance of 20 inches, it is unnecessary to describe the cone or diaphragm otherwise than to give the image diameter produced by it. The smaller image sizes were produced by small lead diaphragms supported at the surface of the water, and the

TABLE II

Thickness of Water in Inches	*Diameter of Image in Inches*	*Ratio Diffuse to Total Radiation Observed*	*Ratio Diffuse to Total Radiation from Curves* $\frac{D}{T}$	*Ratio Scattered to Total Radiation* $\frac{S}{T}$	*Exposure Factor*	*Ratio Diffuse to Primary Focal Radiation* $\frac{D}{F}$
	.56	.12	.12	.08	1.8	.14
	1.30	.25	.23	.20	1.5	.30
2	4.0	.43	.43	.41	1.14	.75
	6.25	.50	.50	.48	1.0	1.0
	20.0	.50	.50	.48	1.0	1.0
	.62	.15	.15	.12	3.0	.18
	1.47	.33	.33	.31	2.4	.49
4	4.0	.57	.57	.56	1.5	1.33
	6.25	.68	.68	.67	1.14	2.1
	20.0	.72	.72	.71	1.0	2.6
	.71	.18	.18	.16	4.9	.22
	1.68	.40	.42	.41	3.5	.72
6	4.0	.64	.65	.64	2.1	1.9
	6.25	.77	.77	.76	1.4	3.3
	20.0	.83	.83	.83	1.0	4.9
	.83	.22	.22	.20	6.7	.28
	1.96	.52	.51	.50	4.2	1.04
8	4.0	.72	.72	.71	2.4	2.6
	6.25	.81	.81	.81	1.6	4.3
	20.0	.87	.88	.88	1.00	7.3
	4.0	.76	.76	.76	3.0	3.2
10	6.56	.83	.83	.83	2.1	4.9
	20.0	.92	.92	.92	1.0	11.5

The first column gives the thickness of water *x*-rayed. The second column gives the diameter of image on the film as determined by the cone or diaphragm used between the tube and the scattering material; this value suffices for the specification of the cone or diaphragm. The dimensions and position of the cone or diaphragm between the tube and the scattering material make no difference

corresponding image diameters vary with the thickness of water; the larger sizes were made with cones, and the largest size, 20 inches, was that produced by the opening in lead glass shield around the tube.

The image diameters given have been corrected for the area of the shadow of the small lead disk. In the case of the smallest image size (made with a ½ inch diaphragm) the lead disk was not used; the ratio of diffuse to total radiation was determined by measurements of the densities on the film of the image of the diaphragm opening and

[3]The final average for all the films exposed under these conditions was 83%, as shown in Table II.

[4]The efficiency of the Bucky diaphragm principle was not determined in the present experiments, but will be investigated in the near future.

the densities (from diffuse radiation) just outside the diaphragmed image.

The third column gives the observed ratios of the diffuse to the total radiation. When these are plotted against thickness of water, a number of the values do not fall on a smooth curve. For the succeeding calculations, values taken from the curves were taken as the most probable values and are tabulated in column 4. The scattered radiation is somewhat less than the diffuse radiation, since the latter includes primary radiation from other parts of the target than the focal spot. The small correction for this deducted from the values of column 4 give the ratios of scattered to total radiation as tabulated in column 5. The method of making this correction is described later.

When scattered radiation is lessened by means of a cone or diaphragm, the decreased intensity of the radiation striking the film necessitates a longer exposure. For each thickness of water, the exposure for a 20 inch image is here taken as the ordinary or standard exposure. The factor by which this exposure must be multiplied to produce the same density of film when a cone or diaphragm further limits the scattered radiation is called the "exposure factor"; these factors are calculated from the values of column 5 and are tabulated in column 6. This calculation is based on the fact that the intensity of primary radiation reaching the film is unaffected by the cone or diaphragm; only the scattered radiation is thereby diminished. Let P_{20} represent the primary radiation, S_{20} the scattered radiation, and T_{20} the total radiation reaching the film with an image diameter of 20 inches, and P_X the primary radiation, S_X the scattered radiation, and T_X. the total radiation reaching the film where the image diameter is X inches. If the total *x*-ray intensity reaching the film is diminished in the ratio of $\frac{T_X}{T_{20}}$ the exposure time must be multiplied by the inverse ratio in order to obtain the same density of film; the exposure factor is therefore $\frac{T_{20}}{T_X}$

Now, $T = P + S$, or $P = T - S$
and $P_X = P_{20}$
Then,

$$\frac{T_{20}}{T_X} = \frac{\frac{T_{20}}{P_{20}}}{\frac{T_X}{P_X}} = \frac{\frac{T_{20}}{T_{20} - S_{20}}}{\frac{T_X}{T_X - S_X}} = \frac{1 - \frac{S_X}{T_X}}{1 - \frac{S_{20}}{T_{20}}}$$

By this equation the exposure factors may be computed from the values of $\frac{S}{T}$ tabulated in column 5.

The number which is the true measure of the effect of the diffuse radiation is the ratio of the diffuse radiation to the primary focal radiation. This ratio is given in the last column; it is computed by the relation $\frac{D}{F} = \frac{\frac{D}{T}}{1 - \frac{D}{T}}$ where $\frac{D}{F}$ represents the ratio of diffuse to focal radiation, and $\frac{D}{T}$ the ratio of diffuse to total radiation, the values of which are tabulated in column 4. For instance, if the ratio of diffuse to total radiation is .80, the ratio of focal to total radiation is 1 —.80 or .20 and the ratio of diffuse to focal radiation is $\frac{.80}{.20}$ or 4.0.

The values in Table II show the large part played by scattered *x*-rays in the radiography of the thicker parts of the human body. Under most conditions the diffuse radiation is by far the major portion of the radiation reaching the photographic surface; under conditions similar to those in the radiography of deep parts the intensity of the diffuse radiation is about 4 to 10 times the intensity of the focal radiation. Its marked effect in reducing contrast and definition can readily be appreciated. The elimination of all or a large part of the diffuse radiation should result in a great improvement in the quality and diagnostic value of radiographs. Diffuse radiation is reduced to a relatively small value by diaphragming the image to a very small size, ¾ inch in diameter or less.

This size is too small to be of much use although it might be of occasional value in such work as studying the fine structure of diseased bone tissue.

Figure 4 shows the curves of ratio of diffuse to total radiation plotted against thickness of water (for the various sizes of cones and diaphragms). The observed values are indicated by small circles. Figure 5 gives the curves of ratio of diffuse to focal radiation plotted against thickness of water, showing the increase of the scattering effect with increase in thickness of water. Figure 6 shows this ratio plotted against image diameter for the various thicknesses of water; the number on each curve represents the thickness of water in inches. This set of curves is the most instructive of any of those shown. For each thickness of water, as the image diameter is diminished from 20 inches, the scattering does not much decrease until a certain point is reached; then as the image size is further diminished the scattering decreases quite rapidly. This effect is most noticeable for the smaller thicknesses. In radiographing through 2 inches of water, no decrease in scattering is produced by diaphragming the image to 6¼ inches diameter. The image size where the scattering begins to diminish appreciably is greater for the greater thicknesses of water. In radiographing through 10 inches of water, diaphragming to anything less than 20 inches produces a marked decrease in the scattering effect. The ordinate value unity represents a diffuse radiation of one-half the intensity of the total radiation. The portions of the curves above this value show the large range of conditions where the diffuse rays form the greater portion of the total radiation reaching the film. It is evident that in using a cone or diaphragm to reduce scattered radiation, the smallest size practicable under the circumstances should be employed.

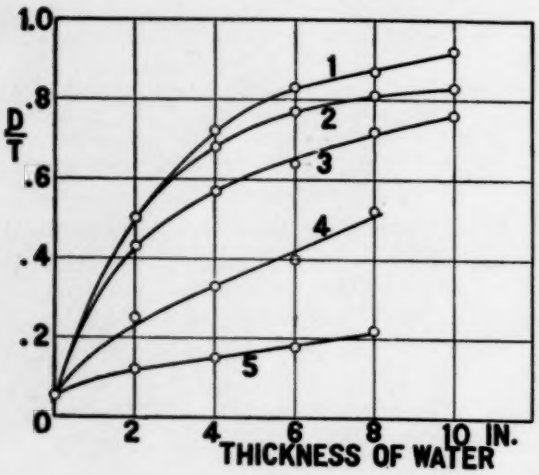

Fig. 4. Curves showing ratio of diffuse to total radiation plotted against thickness of water. Curve 1 is for an image diameter of 20 inches; Curve 2, image diameter of 6.25 inches; Curve 3, image diameter of 4 inches; Curve 4, a diaphragm of 1 3/16 inch diameter at surface of water; Curve 5, a diaphragm of ½ inch in diameter at surface of water.

In order to derive the ratios of scattered to total radiation from the ratios of diffuse to total radiation measured experimentally, it was necessary to determine the proportion of primary radiation reaching the film from other parts of the target than the focal spot.

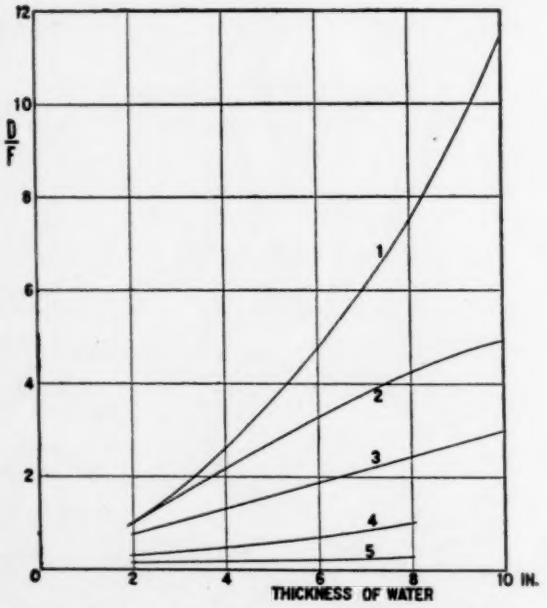

Fig. 5. Curves showing ratio of diffuse to focal radiation plotted against thickness of water. Curve 1 is for an image diameter of 20 inches; Curve 2, image diameter 6¼ inches; Curve 3, image diameter 4 inches, Curve 4, 1 3/16 inch diaphragm at surface of water; Curve 5, ½ inch diaphragm at surface of water.

If in the arrangement shown in Figure 1

the scattering material be omitted, the radiation falling in the shadow of the small lead disk is extra-focal primary radiation. Its ratio to the total radiation was measured by the method already outlined, i. e., by determining the relative exposures required for equal densities of film in the shadow of the

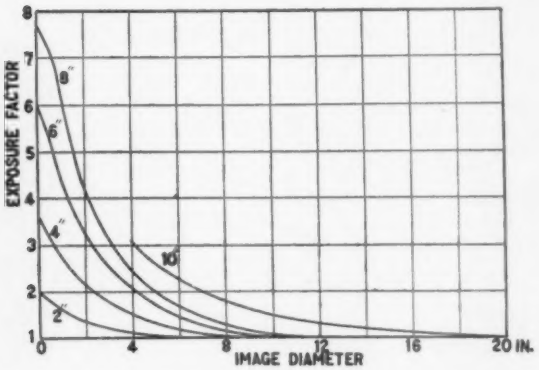

FIG. 6. Curves showing ratio of diffuse to focal radiation plotted against image diameter. The thickness of water is designated on each curve.

lead disk and just outside that shadow. By this method, with no absorbing material between the tube and the film, the radiation from other parts of the target than the focal spot was found to be .053 of the total radiation. This value was found to be about the same for all sizes of cones or diaphragms and for all positions of the small lead disk used in the present experiments. Since the effect of the extra-focal radiation upon the ratios $\frac{D}{T}$ of column 4, Table II, is very small, its precise determination for every set of conditions is unnecessary. The greatest variation in the proportion of extra-focal radiation was produced by the absorbing material between the target and the film. The radiation from the copper of the target is softer than that from the tungsten, and it is therefore absorbed more when matter is introduced between the target and the film. The proportion of extra-focal primary radiation reaching the film when scattering material was inteposed was determined by measuring the relative intensities of radiation reaching the film with the target face turned toward the film and with the target face turned away from the film. By this method with no absorbing material present, the radiation from the back of the target was found to be .041 of the radiation from front of the target. With 4 inches of water this was reduced to .026 or 63 per cent of the value for no absorbing material. With 6 inches of water this ratio was found to be .020 or 49 per cent of the value for no absorbing material. The proportion of extra-focal radiation when the target face is turned toward the film had been found to be .053 with no absorbing material. With 4 inches of water this value should be reduced to 63 per cent of .053 or .033. With 6 inches of water this value becomes 49 per cent of .053 or .026. The determinations for greater thicknesses of water required such long exposures that it was decided not to make them, but rather to use in the computations values extrapolated from the curve of the already observed values. The curve of the ratio of extra-focal primary radiation to total primary radiation reaching the film, plotted against thickness of water, is shown in Figure 7.

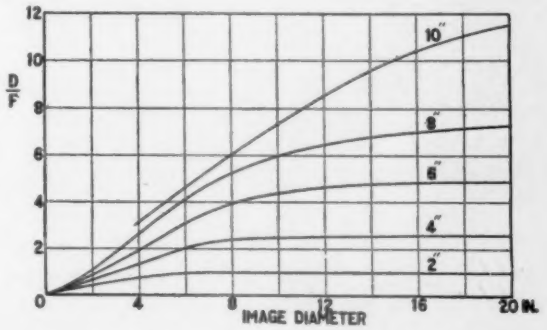

FIG. 7. Curve showing ratio of extra-focal primary radiation to total primary radiation plotted against thickness of water.

It was now required to determine the effect of the extra-focal radiation upon the ratio of diffuse to total radiation. Let P represent the total intensity of the primary radiation reaching the film when a given amount of scattering material is interposed. Let *a* be the fraction of this coming from other parts of the target than the focal spot;

then aP is the intensity of the extra-focal primary radiation and $(1-a)$ P the intensity of the focal radiation. Let S be the scattered radiation, D the total diffuse radiation, and T the total radiation, reaching the film.

Then $D = S + aP$, (1)

and $T = S + P$; (2)

also $T = D + (1-a)P$ (3)

Dividing equation (1) by T, we find that the observed ratio of diffuse to total radiation

$$\frac{D}{T} = \frac{S + aP}{T} \quad (4)$$

Substituting for P its value T — S by equation (2), we obtain

$$\frac{D}{T} = \frac{S + aT - aS}{T} \qquad \frac{S(1-a) + aT}{T}$$

$$= \frac{S(1-a) + a}{T} \quad (5)$$

Whence

$$\frac{S}{T} = \frac{\frac{D}{T} - a}{1-a} \quad (6)$$

Thus by this equation the ratio of scattered to total radiation, $\frac{S}{T}$ may be computed from the experimentally determined value of the ratio of diffuse to total radiation, $\frac{D}{T}$. For example, the value of $\frac{D}{T}$ for 4 inches of water and 6.25 inch image diameter is .68 (Column 4, Table II), and the fraction a has the value .033. Then applying equation (6)

$$\frac{S}{T} = \frac{1 - .033}{.68 - .033} = \frac{.647}{.967} = .67$$

the value recorded in Column 5, Table II.

The values of $\frac{S}{T}$ are required for the calculations of the exposure factors. It will be noted that in the presence of any considerable amount of scattered radiation, the difference between $\frac{D}{T}$ and $\frac{S}{T}$ is quite small, usually about .01 or .02; under such conditions the extra-focal primary radiation is a negligible portion of the total radiation reaching the film, and it is quite small (5 per cent or less) when there is no scattered radiation.

The curves in Figure 8 show the variations of exposure factor with image diameter; the thicknesses of water are indicated by the numbers on the curves. The exposure factors for zero image size are the values computed for the case where all the diffuse radiation is removed.

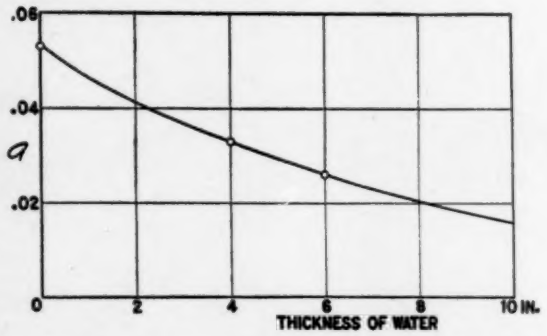

FIG. 8. Curves of exposure factor plotted against image diameter. The thickness of water is designated on each curve.

It may be noted in this connection that the efficiency of a diaphragm under any

TABLE III

Thickness of Composition in Inches	*Diameter of Image in Inches*	*Ratio Diffuse to Total Radiation*	*Ratio Diffuse to Primary Focal Radiation*
2	1.30	.30	.43
	4.0	.47	.89
	20.0	.55	1.22
4	1.47	.35	.54
	4.0	.66	1.9
	20.0	.76	3.2
6	1.68	.46	.85
	4.0	.73	2.7
	20.0	.88	7.3

conditions can be estimated roughly from the exposure factor. For instance, if a given diaphragm necessitates a doubling of the exposure to produce the same density, the total *x*-ray intensity has been halved and more than half of the diffuse radiation has been removed.

With printers' roller composition as the scattering material, the results recorded in Table III were obtained. Most of these values are the mean of three or four determinations and are therefore not quite so reliable as the results obtained with water. For equal thicknesses, the printers' roller composition scatters more than water; the proportion of diffuse radiation reaching the film is roughly the same for equal masses of water and roller composition rayed, i. e., for equal image sizes, a given thickness of roller composition produces about the same proportlon of scattered radiation on the film as a one-third greater thickness of water (density of composition being 1.33).

The effect of tube voltage upon the proportion of diffuse radiation striking the film was studied for a range of spark-gaps from 3 to 9 inches, radiographing through a thickness of 6 inches of water. Table IV shows a summary of the results obtained. The effect of scattered rays upon the film was found to increase slowly with the spark gap. Thus the lowering of contrast produced by increasing the penetration is due in part to the increased scattering as well as the lowered absorption of the image-forming rays.

These data indicate that the scattered radiation affecting the film is slightly harder than the primary radiation, since an increase in the proportion of hard rays in the primary beam increases the proportion of scattered rays reaching the film. This is to be expected from the fact that the scattered rays have traversed a longer distance in the material than the primary rays, and have suffered a corresponding greater filtering action; the soft scattered rays have been thereby absorbed more than the soft primary rays before reaching the film, leaving a greater proportion of hard rays in the scattered radiation.

Contrary to this conclusion, it is sometimes claimed that the so-called "soft secondary radiation" can be screened out by

TABLE IV

EFFECT OF TUBE VOLTAGE UPON PROPORTION OF DIFFUSE RADIATION IN RADIOGRAPHING THROUGH SIX INCHES OF WATER

Spark Gap in Inches	*Ratio Diffuse to Total Radiation*	*Ratio Diffuse to Primary Focal Radiation*
3	.81	4.3
4	.82	4.6
5	.83	4.9
5½	.85	5.7
6	.85	5.7
7	.85	5.7
9	.87	6.7

TABLE V

Filter	*Ratio Diffuse to Total Radiation*	*Ratio Diffuse to Primary Focal Radiation*
None	.83	4.9
1/16 inch aluminum	.82	4.6
1/8 inch aluminum	.80	4.0
.001 inch lead foil	.79	3.8
Thin intensifying screen	.79	3.8

a filter placed between the subject and the plate, with the effect of noticeably improving contrast in the radiograph. This view is evidently due to an impression that the secondary radiation from the human body is largely fluorescent radiation. To test out this point, the proportions of diffuse radiation affecting the film were determined with several types of filters placed between the scattering material and the film, with the tube running at a 5 inch spark-gap. Table V gives the results obtained in radiographing through six inches of water. The filters specified are in addition to the 1/32 inch of aluminum of the bottom of the tank. This thickness of aluminum evidently has some slight influence upon the scattered rays, but its effect is certainly less than the errors of observation. For present purposes, it may be considered part of the scattering material. The various filters are seen to diminish slightly the effect of scattered radiation upon the film; the action of the lead foil and the intensifying screen filters is slightly greater than that for aluminum. The effect of the filters may perhaps be ascribed to the fact that scattered rays making small angles with the film must traverse a greater thickness of filter. While a filter may tend to increase contrast slightly by reducing the proportion of scattered rays, its action in filtering out the softer primary rays tends to reduce the contrast. An experiment to determine the effect upon contrast of a lead foil filter between the scattering material and the film showed that the filter produced no change in the contrast.

SUMMARY

The relative photographic intensities of diffuse and primary focal radiation reaching the film were measured under a variety of conditions, showing the effects of thickness of scattering material, sizes of cones or diaphragms between the tube and the scattering material, tube voltage, and filters placed between the scattering material and the film.

Under conditions similar to those in the radiography of thick parts, the scattered radiation reaching the film is roughly from four to ten times the intensity of the primary focal radiation. The intensity of the scattered radiation is small when the thickness of the scattering material is small or when the x-ray image is diaphragmed to a very small size. Data on the effects of thickness of scattering material and image size are given in Table II, and are shown graphically in Figures 4, 5, and 6.

The removal of any scattered radiation necessitates an increase in exposure, to compensate for the loss in total *x*-ray intensity. The exposure factors corresponding to the various thicknesses of water and image sizes are given in Column 6 of Table II, and are shown graphically in Figure 8.

The ratio of diffuse to primary radiation reaching the film was found to increase slightly as the tube voltage was increased.

Filters placed between the scattering material and the film diminish slightly the proportion of diffuse radiation; the filters are of no practical value, however, inasmuch as they do not improve radiographic contrast.

REMARKS ON THE MEASUREMENTS OF SCATTERED RADIATION

By MILLARD B. HODGSON

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THE application of roentgenology of the figures in Mr. Wilsey's paper on scattered *x*-rays promises most valuable results, for the writer believes that this is one of the faw contributions of quantitative measurements of scattered *x*-rays that can be directly applied in practical work.

A number of physicists—Barkla, Hull and

others— have derived physical laws governing the absorption and scattering of *x*-rays by matter, but such figures are exceedingly difficult to apply in roentgenology. Mr. Wilsey's results, on the other hand, may be applied to such problems as radiography and therapy, for the empirical formulae derived contain only those factors that exist in these phases of *x*-ray science. For example, not only can it be seen that, as the diphragm aperture is reduced, the volume of scattered radiation reaching the film is reduced, but the proportional reduction of scatter may be computed directly and the necessary change in exposure time compensated for.

To illustrate: A kidney negative is taken at 25 inches target-film distance, using a diaphragm that covers a 20 inch circle at the film. Let us assume that eight inches of tissue are passed through. The result is a gray, foggy negative with very little detail, for the effect of the image-forming rays has been neutralized by the general fog produced by the scattered rays.

A study of Mr. Wilsey's charts shows that under such conditions the scattered radiation reaching the film has a value equal to 88 per cent of the effective radiation striking it. That is, only 12 per cent of the exposure is image-forming—the rest is obscuring detail.

Substituting a diaphragm that reduces the circle of illumination to 4 inches in diameter, we see that the effect is to reduce the scattered radiation from 88 to 71 per cent, with a proportional increase in the effectiveness of the image-forming rays.

The increase in exposure time necessary to compensate for the loss in total radiation is also given in the tables. For this theoretical case it is necessary to multiply the exposure by 2.4.

It is well this latter fact in mind in work with the Potter-Bucky diaphragm, for the reduction in scattered radiation is analogous to the foregoing. In the average type of Potter-Bucky diaphragm on the market at present the time factor is about 3 or 4. In fact, unless such a diaphragm does have a factor of this order, it would be of very low efficiency, for it would mean that there was very little reduction in the volume of scattered radiation striking the film.

This time increase makes it desirable in a great many cases to use intensifying screens, and Mr. Wilsey's data on the most effective use of these should be studied.

The method used in the paper in question offers a simple means of testing other methods of diaphragming, for all the apparatus necessary is a small cylinder of lead and dental films; at least for a qualitative estimate.

It seems that further applications of these results should be in the field of therapy, for here, obviously, the important thing to know is how much radiation is reaching each cubic centimeter of tissue, and it is evident that this may be computed, at least approximately, from the figures given; certainly with more accuracy than assuming a straight logarithmic absorption law or attempting to deduce from physical measurements of absorption coefficients.

In all such applications it should be borne in mind, however, that the improvement in quality of the image obtained is of such an order of magnitude that errors in technique, especially in the dark room in the case of making negatives, might easily obscure it; therefore the more urgent is the need of standardization in technique, for obviously it would be of little use to remove an obscuring fog by diaphragming and later introduce as dense a fog or a heavier by improper development.

THE BUCKY DIAPHRAGM*

By H. W. VAN ALLEN, M.D.

SPRINGFIELD, MASSACHUSETTS

ONE of the most successful roentgenologists recently said that the moving Bucky diaphragm is the greatest advance in our science since the advent of the Coolidge tube. Great credit is to be given to Dr. Hollis Potter of Chicago for the development of the present status of the method of application of the idea introduced by Bucky of Germany. The original diaphragm produced a radiograph covered by lines running in both directions, the result appearing as though viewed through a grating, and was not a practical procedure. Dr. Potter's method of moving the grid during the exposure has given us a radiograph that is not only practical in its results but startling in its efficiency.

The few moments I shall speak to you I will divide in three portions:

First. A description of the principles of the diaphragm;

Second. The mechanical devices that aid in making a diaphragm satisfactory, and

Third. Some points in the use of the instrument that have been of aid to me.

I presume most of you know the principles involved in the Bucky diaphragm, but I am equally certain a few do not, so I will ask those in the first class to bear with me during a brief description.

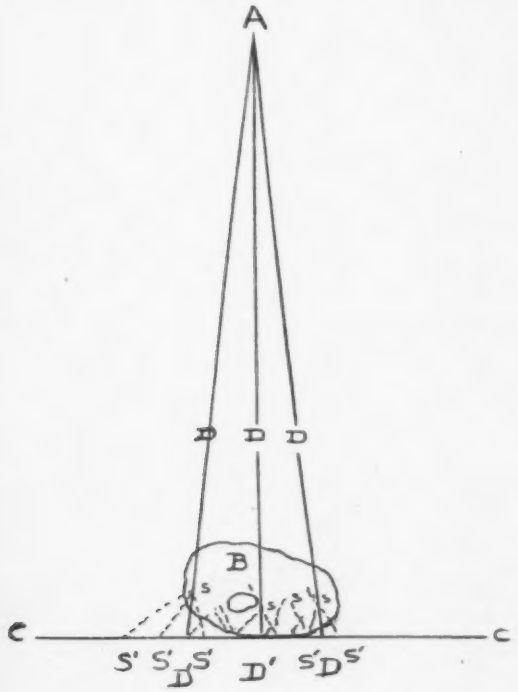
When the roentgen ray is passed through resisting substances, secondary rays are given off by this substance. These rays go in all directions. Their excursion is short, but they come from all directions and are more in quantity than the primary ray. These are the rays that fog our plate, making them hazy through the thicker parts of the body, and produce a limit to our ability to examine successfully very large persons. The whole purpose of the Bucky diaphragm is to cut off or strain out as it were the major part of these rays and leave the direct rays unchanged. Probably I can illustrate this in the quickest manner by demonstrating with two charts similar to those published by several authors.

The whole function of the apparatus is to prevent the secondary or fogging rays from striking the plate. Their angle is such that they cannot pass down through the narrow spaces between the lead strips, but striking the lead are prevented from reaching the plate, while the primary ray meets with no such interference and a plate results practically clear from fog.

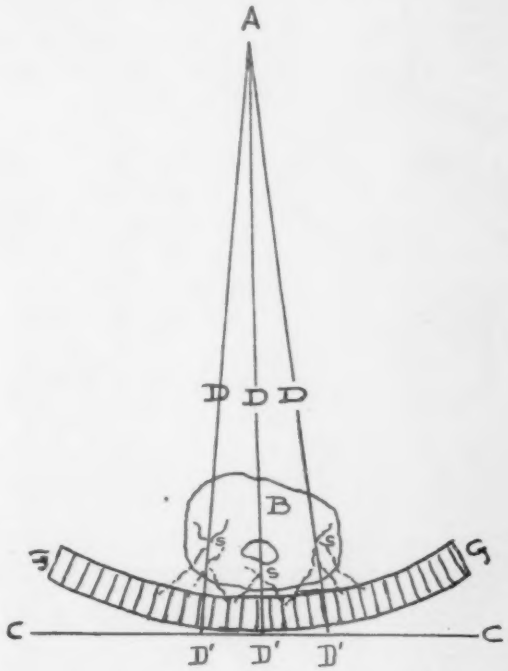
As to the mechanical perfection of the diaphragm many things are necessary for success. Naturally, one thinks first of the grid. It must be strong and yet light in weight. This we accomplished by making the frame of huron metal—as strong as steel and as light as aluminum. The wood strips of which the grid itself is made up must withstand weather conditions. All wood swells and shrinks with atmospheric changes. Springs are placed at each end, which keep the slats pressed together under all circumstances. An open question is the placing of the lead strips. We experimented with various models and got the best results with about six strips to the inch of three-quarter inch thickness. When the lead strips are closer together the actual amount of lead becomes a factor in making the exposure longer. It is self-evident that the width of the strips does not retard the ray but only the thickness of the lead, so twice as many strips produce twice as much cutting off of the direct ray. The lead used was one half of one hundredth of an inch in thickness. It is also manifest that the wider the strips the more of the secondary rays are cut off. But after a little another disadvantage comes in; that is, the increasing distance between the patient and the plate. Up to three quarters

*Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., January 28, 29, 1921.

of an inch there seemed to be no difference; beyond this there came distortion. The lead strips should go entirely through the grid, as any other method only increases the patient-plate distances, which is one of the defects of this method of examination. Hollowing out the strips in the center of the sides makes them pinch only on the edges. The wood strips must be narrower on one edge to insure perfect direction of the lead strips toward the central point 25 inches away or the focal point of the tube. The motion of the grid must be uniform. We tried several methods and found two springs better than one, as any friction in one was replaced by the action of the other. A grid should move in any position with equal ease. It is important not only to be able to make the exposure with the patient lying on the diaphragm but also with the patient standing and the diaphragm at his back for sacro-iliac joints. Again, if the diaphragm will work in that position it can be placed at the side of the patient and obtain beautiful radiographs in pneumoperitoneum. Ball-bearing rollers on each side a "V" shaped projection on the grid insure this result. The check to regulate and make the speed uniform is the commonly used principle of a fluid passing through an opening in a piston head. A very satisfactory arrangement was made whereby this valve can be regulated by turning the piston rod. This made necessary only a single rod, projecting from the diaphragm, for setting and regulating the speed. Also it was found that this same valve, by means of a retaining spring, could be used for the return of the fluid, which obviated the necessity of a by-pass. The next essentials were placing and holding the plate. This is easy when the diaphragm is flat, but more difficult in the vertical position. Not only this, but the plate must be held in any place under the grid, and for stereoscopic work must be replaced



A = focal point.
B = object to be radiographed.
C = plate.
D = primary ray.
S = secondary ray.



S' = points where the secondary ray strikes the plate.
D' = points where primary ray strikes the plate.
G = grid composed of lead strips supported by intervening wood strips.

in exactly the same position again. A removable pan with lugs accomplished this for us.

Many minor things come to one's mind when working with a new instrument of this kind, as a method of centering the tube, a bell for notifying the operator when the motion of the grid is about over, and handles for ease of placing the diaphragm in position. Some method of stabilizing and compressing the patient is of great value, especially in the upright position.

As to some of the practical points in working with this diaphragm, I am most often asked about the time of exposure. A great deal more than 50 per cent of the photo-chemical effect on the radiographic plate is produced by secondary radiation. Therefore the better the Bucky diaphragm the longer will be the exposure to produce a given amount of darkness on the plate. The more secondary or harmful rays that are cut out the more primary rays will be needed. In actual practice however the time of exposure is not greatly lengthened, as with no more fear of the large amount of secondary rays set up by hard primary rays, longer spark-gap becomes a distinct advantage in penetrating the head and torso of large patients. This is particularly true in the case of those of us who have been using short spark-gaps in our work. Those already using long spark, of course, will of necessity increase the time of exposure when using the diaphragm. The larger the patient the harder the ray required and the more secondary rays produced. These are cut off by the diaphragm, so this makes it possible to say, relatively speaking, the larger the patient the better the plate.

When is it best to use a diaphragm? On all thick parts. When, however, we get down to about three inches of flesh the advantages of the diaphragm are offset by the distance of the patient from the plate and it is no longer of use.

Must the tube be just 25 inches from the plate? No, but placing the tube nearer or farther away causes the direct ray to strike the lead strips not exactly on edge but makes the shadow of the strips wider and this increases the obstruction and length of exposure, which in the case of more than 25 inches added to the distant effect multiplies rapidly. The upright position becomes very valuable in showing ptosis of organs, as the stomach, kidney, etc.; also luxation of the sacro-iliac joint and fifth lumbar vertebra. Side-to-side plates become of value when taken with the added clearness obtained by this method.

A very practical caution I wish to call to your attention is the danger of a burn. These patients are usually large. Were it not for the 25 inches required by the grid one would naturally increase the distance. By not doing so the skin target is quite short. Some defect in the technique may have caused you to get a corresponding defect in the plate. Care must be used not to get an erythema skin dose by repeated exposures.

The grid must be in motion during the entire exposure; the least variation from this rule will give undesirable lines. If for any reason it seems desirable several excursions of the grid may be made for a single radiograph.

I have of late been using a curved cassette with considerable advantage. The curve is the same as that of the grid. In this way all parts of the film are equally distanced from the focal spot and receive equal energy. Each ray strikes the plate at right angles and consequently there is no distortion, and the fuzzy appearance, so common in objects distant from the plate, is obviated. It is also evident that a film curved in this way will cover more of the cone of rays coming from the focal spot than the same plate straight at the distance of the center of the cone.

In conclusion I submit that the Potter-Bucky diaphragm has come to stay as a great aid to roentgenologists. Its final form may be quite different, but the principle is permanent.

SOME ACCESSORIES TO THE POTTER-BUCKY DIAPHRAGM

By DAVID RALPH BOWEN, M.D.

Roentgenologist, Pennsylvania Hospital

PHILADELPHIA, PENNSYLVANIA

ESTIMATES of the value of the Potter-Bucky diaphragm as an advance in roentgenography will, doubtless, vary considerably among roentgenologists. But among those who have mastered its technique, we are sure these estimates will all be high. It is hardly conceivable, for the present, that one who has learned to use this device successfully will be content to do without it.

There are, however, serious practical objections to the apparatus as at present delivered by the various makers. The equipment used by Dr. Potter, in which the diaphragm is adjustable under a canvas stretcher on which the patient reclines, is ideal; but very few have the discarded apparatus which Dr. Potter utilized in his office, and to construct such an apparatus *de novo* entails an expense which many will wish to avoid.

The apparatus here described has proven practical. It obviates all necessity of handling the heavy and somewhat unwieldy apparatus and since we have had it we notice an inclination to increase, rather than decrease, the number of cases in which we use it.

It consists primarily of a simple wooden table constructed at the Pennsylvania Hospital by the house carpenter. The top of the table is made to conform to the curve of the diaphragm, from which it extends two feet on one end and three feet on the other, making a table practically seven feet long, with a recess into which the diaphragm sets so as to be flush with this curved top. In use, a folded bed-sheet is always laid lengthwise of of the entire table and upon this the patient is placed. Even with patients weighing two hundred pounds and over it is not difficult to shift them lengthwise of the table to any desired point by pulling on one or the other end of the sheet. If the top of the table is properly polished this maneuver will be found surprisingly easy; and it is believed that the centering can actually be done in less time than by any of the various mechanisms which might be suggested for the purpose.

Having proceeded this far it becomes desirable to center the tube over the diaphragm after the patient is in place. This is accomplished by a device which we may call a bridge, illustrated in the cut at A. By appropriate marks on either side of the diaphragm, this bridge is readily placed so that a hole

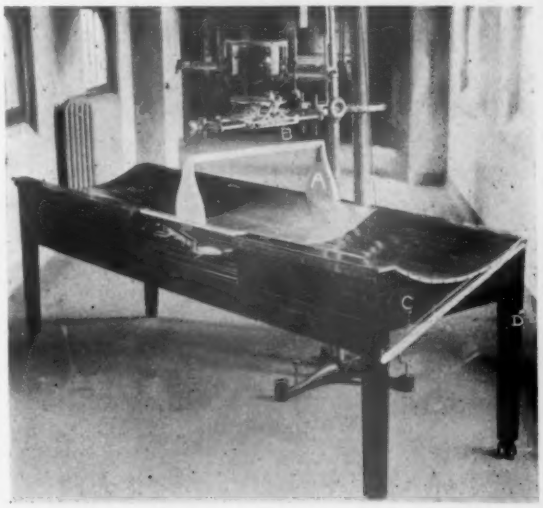


Fig. 1. Showing table described with the diaphragm, bridge and tube in position.

through the top of it is directly perpendicular to the top of the diaphragm, and twelve inches above it. By means of a plumb-bob, illustrated at B and elsewhere described[1], the focus spot of the tube is centered directly over this mark on the bridge and thirteen inches above it. If a single exposure is to be made, the tube-stand is fastened at this point and both the bridge and plumb-bob are removed. Stereoscopic exposures are accomplished by dividing the stereoscopic shift,

[1] *Am. J. Roentgenol.*, February, 1918, V, 60.

half toward the head and half toward the feet, from this center point. (Because of difficulty in lighting, a tube-stand has been used in the accompanying illustration which does not permit shifting in this direction.)

It is vitally important, in using this diaphragm, that the operator should know, all the time, just what proportion of the excursion of the diaphragm has been accomplished. A bell which rings near the end of the exposure is of doubtful utility and frequently disturbs the patient, when such disturbance is least desired. We have adopted a signal device, illustrated at C, one end of which is connected by a cord with the moving member of the diaphragm. During the excursion, the end of this pointer travels from the high point at which it is illustrated to the white spot at D. This arrangement permits constant visibility of the excursion in the position in which we work. It could, of course, be arranged at either end or even above the table.

These suggestions are offered as having greatly increased our efficiency in the use of this instrument and as, perhaps, being adaptable by variations to many other laboratories. Dr. Manges has, for instance, found it possible at the Jefferson Hospital to have both table and tube-stand in a fixed position, so that it is necessary only to center the patient on the table.

Perhaps no one factor has caused so much disappointment in the use of the Potter-Bucky diaphragm as the lack of contact of the film with double intensifying screens. We have found that a set of six wooden wedges, forced under the ends of the three springs on the back of the cassette, has almost eliminated this trouble. Such a proceedure is crude, of course, but, pending the time when cassettes which really force contact between film and screen over the entire surface are obtainable, we believe that this maneuver will more than repay the little extra effort which it entails.

DISCUSSION OF DR. J. H. ULLMANN'S PAPER

"Practical Application of the Sphere Gap to Roentgenotherapy"

(Published in the April Issue)

Dr. J. G. Van Zwaluwenburg. I should like to ask Dr. Ullmann if the error does not become progressively greater as you increase the filtration, and whether minor differences in penetration do not produce disproportionately large fluctuations in the quantity of the emergent ray, because of the relatively greater absorption of the softer ray compared with the harder ray. This might have a very important influence in our determination of the standard erythema dose for the individual machine and "set up."

Dr. Hollis E. Potter. First, Dr. Ullmann has shown that there is a discrepancy between supposed and actual voltage of as high as 35 or 40 per cent. This discrepancy is enough to account for the difference between burns and under-dosage.

Second, peak voltage is one of the most important factors in determining the dosage, since it is one of the two factors that vary according to the square.

It is accepted among engineers that the sphere gap is the one best way to measure the voltage of high tension currents, and it is about the only way to standardize a given machine so that it can be made to duplicate results obtained on other apparatus.

It is to be hoped that the manufacturers of apparatus to be used in therapy will provide suitable sets of sphere gaps that can be used by therapists. It is not for routine readings for the occasional verification of their voltmeters.

Dr. H. J. Ullmann. I spoke of using 6.25 or 12.50 cm. spheres because one can get tables showing breakdown voltage for these sizes. I used a 12.50 cm. sphere for this work (12.50 cm. is about 5 inches) as it is the most convenient size for the range of voltage that we have to measure. My apparatus will go to

about 180 kilovolts effective before it reaches the limit of the dimensions laid down as a standard.

For accurate work the longest gap should not be greater than the diameter of the spheres but in practice a gap not more than three times the radius may be used. The sphere diameter should not vary more than 00.1 per cent. or the curvature more than 1 per cent from a true sphere. The spheres should be at least twice the gap setting from surroundings and the shanks not greater than one-fifth the sphere diameter.

In regard to filtration I have some figures here based on the work of Dr. Hall of Schenectady, published in the *Proceedings American Institute Electrical Engineers.* Approximately 50 per cent of all the rays passing through 5 mm. of aluminum at 90 KV effective are of the very hard order and at 80 KV the proportion is 4 per cent lower, i. e., 46 per cent. Also according to Dr. Hall's curve if the volume of ray of about 0.2 angström in length is 60 at 80 KV, it will be 100 at 90.

In regard to the question of motors in direct current machines these tests, with one exception, were all made on alternating current outfits. There is no variation in voltage readings at different cycles within the commercial range. I do not know if the readings would be affected by variations above or below these.

I would like to ask Mr. Darnell to tell us if there would be a variation under conditions liable to be met with in our work.

MR. DARNELL. I am not sure; it depends upon circumstances. It is very likely a change in speed on machine would change the speed of all waves, and point-gap machines differ. It is very likely the sphere gaps between the machines are equal—you might say so far as we know. It is the heat of wave which is important so far as therapy is concerned.

MR. ANTE. The diameter of the sphere is the exact diameter of the spark gap.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

H. M. IMBODEN, M.D., *Editor* · PAUL B. HOEBER, *Publisher*

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

TWENTY-SECOND ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY

WASHINGTON, D.C., SEPTEMBER 27, 28, 29, 30, 1921

Headquarters, Meetings and Exhibits: Hotel Washington. Hotels: Hotel Washington and The New Ebbitt.

WASHINGTON MEETING

The Twenty-second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY will be held in Washington, September 27, 28, 29 and 30, 1921. Headquarters, meetings and exhibits will be at the Hotel Washington, Pennsylvania Avenue, opposite the Treasury.

Hotel accommodations for members and guests may be arranged at the Washington Hotel and The New Ebbitt. In making reservations state that you are attending the meeting of THE AMERICAN ROENRTEN RAY SOCIETY. Mr. A. Gumpert, Manager of the New Ebbitt, has agreed to see that all those attending the Convention are taken care of. Therefore anybody not getting what he wants should communicate direct with him.

The hotel rates are as follows:

Hotel Washington, every room having private bath with shower, tub and running ice water (European plan only):

	Per day
Single rooms	$5.00 to $7.00
Double rooms (double bed)	8.00
Double rooms (twin beds)	10.00 to 12.00

The New Ebbitt (European plan only):

	Per day
Single room without bath	$2.50
Single room with bath	4.00
Double room without bath, each person	$2.50
Double room with bath, each person	3.50

Also a number of large suites, both with and without bath, which will comfortably accommodate upwards of four persons. On these suites they would make a rate of $3.00 per day each person, with bath, or $2.00 per day each person without bath.

For information regarding the program, those wishing to read papers or to show slides at the meeting should communicate direct with the President, Dr. A. C. Christie, 1621 Connecticut Avenue, N. W., Washington, D. C.

For information regarding commercial exhibits and other business matters connected with the meeting, address the Business Manager, Paul B. Hoeber, 67-69 East 59th Street, New York City.

It is hoped to arrange for special trains and cars from various sections. Details regarding this will be announced later.

PRELIMINARY ANNOUNCEMENTS

Dr. A. C. Christie, President of the Society, announces that plans for the program of the Annual Meeting of the Society next fall are now well under way. Dr. Réné Ledoux-Lebard will give the Caldwell Lecture on the subject of "Deep Roentgen Therapy." It is planned to give a much larger place on the program to papers on therapy than has hitherto been done. The plan is to hold the meeting for four days, giving the entire first day to papers on therapy and to have the papers on physics during the forenoon of the second day. This will enable those who are interested only in therapy to leave about the middle of the second day, while those interested only in roentgen diagnosis would not feel it neces-

sary to attend until the beginning of the second day. Those interested in both diagnosis and therapy would probably wish to be present the entire four days.

It is believed that this plan will make the meeting of interest to a much larger number of men. It is requested that those who have papers to present at the meeting communicate with the President of the Society at as early a date as possible.

X-RAY WORK FROM THE VIEWPOINT OF AN INTERNIST

The address by Dr. George Dock before the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY is of more than passing interest. It is an appraisement, a critique, and an appeal. The roentgenologist whose medical training fits him to respond to this address will find therein a powerful incentive not merely to do better work but to do the best work. The words carry unusual weight because they were uttered by the one internist of the English speaking world upon whose shoulders has fallen the mantle of William Osler.

Dr. Dock's interest in *x*-ray work began with Roentgen's discovery. He watched it at first-hand abroad and at home. On his invitation the writer gave the first talk on the *x*-ray examination of the chest delivered at a great University where for many years he held the chair of medicine. It was due to his influence that the same University obtained its first appropriation of funds for an *x*-ray installment. His interest in this revolutionary means of diagnosis has expanded with its development, although he has never himself undertaken the technical part of the work.

But he has never ceased to be the skillful and cultured internist. The traditions of the great masters are no less dear to him now because a new science of diagnosis is being written. The stethoscope, the microscope and the test tube are still no less important because of the revelations of the tube and film. The fine art of taking histories and of making the physical examination is now, no less than in the days of Laënnec, the foundation of the diagnostics of internal medicine.

These ideals of the internist he would plant in the minds of the roentgenologist. The search for the pathognomonic sign, like the search for the philosopher's stone, is futile although strangely fertile in unexpected fruit. The work of diagnosis is not shortened by the discovery of new methods. It is amplified and more accurate, but yet in need as much as ever—perhaps more than ever—of the correlating power which comes only from a complete knowledge of the patient. The roentgenologist must refrain, therefore, from issuing diagnoses upon *x*-ray premises but give instead roentgen interpretations.

Doctor Dock's address is not sugar-coated. His criticisms are sharp and basic. His acidulous remarks are destructive of inferior methods but preservative of the best. However perfect may become *x*-ray technique and however skillful the roentgenologist, yet in the accumulated experience and achievement of pre-roentgen times lies a body of diagnostic methods which the medical world will never willingly let die.

However much we may admire the vigor, sanity and insight displayed by Dr. Dock we cannot but take issue with him over at least one point. This is the statement that the roentgenologist has never satisfactorily demonstrated his reasons for deciding upon the activity of a tuberculous lesion in the lung from a single examination. If he had said that the activity or quiescence of such a lesion cannot always be decided by a single examination we would unhesitatingly agree. In fact in a previous editorial in the JOURNAL we emphasized the difficulties and dangers of diagnosticating activity from single *x*-ray examinations and urged the use of serial plates. But we believe that the pages of the JOURNAL and the works of many roentgenologists without regard to nationality have clearly defined the distinctive attribute of the active pulmonary lesion when found on the *x*-ray plate. Un-

fortunately it is not present in all stages of activity or in all types of pulmonary tuberculosis. But when found it surpasses all other clinical signs in directness and simplicity. It is merely the nebulous, borderless character of the shadow of activity. Form and distribution may also be at times decisive factors, but it is the nebula which marks the focus in active evolution, the final end of which is the smaller dense calcification of quiescence.

The nebulous quality of the shadow depends upon the fact that activity means inflammation and inflammation means increased blood, serum and leucocytes in the lung tissue and these in turn mean density. The nebula may be parenchymatous or lymphatic or it may be seen as a halo about a calcified focus not yet wholly quiescent. Classifications still vary, but by lymphatic we mean a line or stalk of nebulous density running to the hilum from a small calcified particle well out in the lung field. In some cases scores of these radiation nebulous drainage lines may be traced, each one starting from a calcified particle about which is a soft halo. These may be seen best on stereoscopic films using double screens, the briefest possible exposure with a soft tube, and a long distance between tube and patient.

It may also be asserted and defended that good *x*-ray plates are always right and that only the interpretation is wrong. If a "large pneumothorax" or a "fairly extensive tuberculosis" is missed by the roentgenologist it is the man and not the method that is to blame. We cannot but believe that any pulmonary lesion which brings about changes in density is susceptible of *x*-ray demonstration.

The limits of an editorial allow us to be suggestive merely and we leave to other and more capable hands the full exposition of these and other points which Dr. Dock flings out as a challenge. We need the stimulus of such handling. We regret that he let slip the opportunity for good-natured but invigorating sarcasm regarding the roentgen diagnosis of gallstones. We are satisfied, however, that he has left few fallacies unprodded so far as the roentgen diagnosis of chest lesions is concerned.

There are two sides to every question. We enthusiastically agree with Dr. Dock that *x*-ray interpretation is greatly assisted by clinical data. But the converse is doubly true. Not only are clinical findings frequently reinterpreted by *x*-ray means but the internist himself has been trained to a skill formerly unattainable in thoracic diagnosis by the repeated disclosures of plate and screen.

In the last analysis the plate and screen are but the added resources of the internist. The thermometer, the stethoscope and the whole clinical laboratory were at first fought and disciplined before they were adopted as legitimate members of the family. We have reached the stage of being disciplined. May we not turn the tables and adopt the internist as a legitimate roentgenologist?

A. W. Crane.

EXTERNESHIPS AT MOUNT SINAI

There has been established at the Mount Sinai Hospital, New York City, a system of externeships in the *X*-Ray Department. There are to be two externes, each serving one year, one beginning February 1st and the other August 1st. The next appointment begins on August 1st, 1921.

OBITUARY NOTICE

The announcement has just been received of the death of Dr. Heinrich Ernst Albers-Schönberg, of Hamburg, an Honorary Member of The American Roentgen Ray Society. Dr. Albers-Schönberg died on June 4th at Allgemeines Krankenhaus St. Georg, Hamburg, from pneumonia. He was in his fifty-seventh year. An obituary will be published in a later issue of the Journal.

BOOK REVIEWS

SURGERY, ITS PRINCIPLES AND PRACTICE. Edited by William Williams Keen, M.D., L.L.D. 855 pages, 359 illustrations, 17 of them in colors. W. B. Saunders Company, Philadelphia.

This volume of Keen's Surgery is one of two volumes designed to complete this standard work on surgery up to the year 1919. Dr. Keen states in the preface that "these volumes do not only record the achievements of surgery from 1914 to 1919. They also fulfill a second purpose I have had in view, viz.; they make available for the surgery of peace the lessons taught us during the war."

Some of the chapter, such as those on "Inflammation" and "Syphilis," are supplementary to chapters in previous volumes. The high standing of the authors of these chapters is sufficient guarantee of their excellence.

A large part of the volume deals with war surgery, either directly or in its effect upon the surgery of civil life. This is indicated by such chapter headings as the following: "Organization and Administration of the Medical Department of the United States Army in War"; "Organization and Administration of the Medical Department of the United States Navy in War"; "Surgery in a Fighting Ship"; "'Traumatic' Hysteria including so-called 'Shell Shock'"; "The Bacteriology of War Wounds"; "Gunshot Fractures"; "The Pathology of Gunshot Wounds and other Injuries of the Nervous System"; "Military Surgery of Joints"; "Military Orthopedic Surgery," and "Military Surgery of the Vascular System."

The entire volume will undoubtedly take its place as a valuable part of a standard work on surgery which is itself quite invaluable to any one practicing surgery in any of its branches, or any specialty related to surgery.

It must seem to the roentgenologist, however, that the object of the author to "make available for the surgery of peace the lessons taught us during the war" has been quite inadequately met, so far as roentgenology is concerned. This is especially noticeable in the chapter by Ashford on "Organization of the United States Army in War." The service rendered by the *x*-ray during the war both to the internist and to the surgeon was so generally recognized that there seems to be little ground for argument on that point. The development of the bedside roentgen apparatus was carried to a high degree of perfection. Its use in assisting in the diagnosis of empyemas and numerous other complications during the influenza epidemic can hardly be overestimated. Since the war this apparatus has come into general use in civil institutions. The importance of the *x*-ray in determining the presence and in the localization of foreign bodies was so well recognized that it merits more than the casual mention accorded it. Possibly such considerations were thought to be beyond the scope of Colonel Ashford's chapter. Several pages, however, are given over to a description of portable laboratory apparatus and no mention whatever is made of portable *x*-ray apparatus. The portable *x*-ray apparatus developed by the Medical Department of the U. S. Army was a great advance over such apparatus used by other armies both in its portability and efficiency. It was used to do the unprecedented amount of *x*-ray work in evacuation hospitals, served as the *x*-ray equipment of mobile hospitals, and even some field hospitals, such as those with the 1st, 2nd and 3rd Divisions, were equipped with it and used it extensively.

The above criticism does not apply to the article on "Military Surgery of the Vascular System" by Matas. He states that "The extraction of foreign bodies from the heart, pericardium, and great vessels constitutes one of the crowning triumphs of surgery in the late war." This was due to two factors—the greater frequency with which artillery projectiles and explosive shells were used and the "more systematic and routine examination of thoracic organs by *x*-ray, not only radiographically, but radioscopically, which has revealed the presence of projectiles in the heart, pericardium, and great vessels where their presence was not even suspected." Ombredanne

and Ledoux-Lebard are quoted to the effect that examination of French sources shows a total of 2,000 extractions of projectiles made with assistance of radiographic and other localizing apparatus, with failure to extract the bodies in only three cases. It is impossible at the present time to give an estimate of operations on the heart for extraction of foreign bodies in all the armies, but accessible reports are sufficient to prove that "a deliberate, well planned surgical operation, especially in qualified hands, can be performed with a fair prospect of success."

Numerous cases are mentioned of migration of foreign bodies from the heart chambers into the blood vessels, both through arteries and veins, and also of migration from the vessels with lodgment in the heart.

Summary of the lessons bearing upon surgery of heart in general and upon extraction of foreign bodies in particular is as follows:

1. The indispensable association and collaboration of the radiologist with the surgeon for diagnostic and surgical purposes.

2. The proved efficiency of this combination has added vastly to the safety of intra-thoracic manipulations and to procedures for the extraction of foreign bodies which hitherto had been regarded as largely impracticable.

3. Modifications in the technique of thoracotomy which, utilizing the older suggestions and methods, have been revised and extended in the light of a new and larger experience.

4. The disregard of the pleura and of the risks of acute surgical pneumothorax, contrary to all preconceived notions of the gravity of this complication in antebellum days.

The radiologic peculiarities of projectiles in the heart are discussed. Radioscopy is preferable to radiography. In the auricular cavities according to Laurent of Brussels, M. Barnet, and Ledoux-Lebard, the foreign body has a whirling or oscillatory movement and exhibits very rapid and incessant motion. In the ventricles the movements are more definitely linear or pendulum-like in character. The movement of missiles in the myocardium is characteristic. One motion is vertical and the other horizontal and quite invariable, in contrast to the variable movements of a foreign body in one of the heart cavities.

It is impossible within the limits of this review even to touch upon many of the points discussed in this article. The entire section merits very careful study by the surgeon and roentgenologist.

In the chapter by Pool on "Military Surgery of the Joints" is the following paragraph:

The success of the operation depends largely upon the thoroughness of the roentgenologist's examination and the accuracy of his findings. His report should be made according to a definite system. The following routine has been found the most satisfactory.

"Anatomic site and size of each foreign body in millimeters, depth in millimeters, position of the part, if it is not in the anatomic position; bone lesions. For instance, 'Right knee, FB 10 x 15 mm., 50 mm. in depth, under the point marked on the skin, the limb being in 45 degrees outward rotation; comminuted fracture of internal condyle, no displacement."

In the chapter on "Orthopedic Surgery of Civil Life" is a paragraph on *x*-ray diagnosis of tuberculous bone and joint disease and on page 614 a description of the *x*-ray appearances in rickets.

It is to be hoped that the forthcoming volume of the *Surgery* will contain some account of the *x*-ray work done during the war, along many other lines, comparable to that in the section by Matas on "Military Surgery of the Vascular System."

A. C. Christie.

Roentgen Interpretation; A Manual for Students and Practitioners. By George W. Holmes, M.D., and Howard E. Ruggles, M. D. Second Edition. Pages 228. Illustrations 184. Price $3.25. Lea & Febiger, Philadelphia and New York, 1921.

This book has been entirely rewritten and much has been added to the text. Illustrations have also been added. The quality of the paper used in the present edition is much better than in the first, and this greatly enhances the illustrations. The table indicating the appearance of centers of ossification is of extreme interest. The chapter dealing with heart examinations describes the method in use at the Massachusetts General Hospital for the past five years and should be in everyone's possession. The illustrations are good.

TRANSLATIONS & ABSTRACTS

WITHERS, SANFORD. Carcinoma of the Eyelids Treated with Radium. (*Am. J. Opth*, January, 1921.)

Eight cases are reported as representative of over one hundred similar cases. In most of the cases, from 25 to 50 mg. of radium were used, filtered by the glass capsule wall and 0.2 to 0.3 mm. of silver and 0.5 to 1.0 mm. of gum rubber. The surrounding tissues were protected by lead. In those cases where it was imperative to protect the globe and the ocular conjunctiva, Dr. Withers used oval lead screens, molded to fit the globe. These were dipped in melted paraffin, and were introduced after the instillation of a few drops of liquid vaseline. The total dosage varied from 500 to 900 mg. hours; the dosage per square centimeter of tumor surface ranged between 60 and 500 mg. hours. Pathologically these growths of the lids are made up of basal cells, with little stroma, and are relatively benign. In the presence of scar tissue, which breaks down easily under radiation, the results are less favorable. The author calls attention to the fact that cataracts disappear under radium, and that cautery doses of radium remove pterygia. The sclera is very resistant, even to cautery doses of radium, and the conjunctiva reacts more quickly and is more rapid in its repair than the epithelium of the eyelids. In general radium is the method of choice in the treatment of carcinoma about the eyelids.

LOWELL S. GOIN

QUICK, DOUGLASS. Clinical Results of Treatment of Nerve Tissue Tumors by Radium. (*Proc. N. Y. Neurol. Soc.; J. Nerv. Ment. Dis.*, February, 1921.)

The general opinion is that pressure symptoms due to pituitary tumors may be relieved by the use of radiation. Three cases are reported, of which one died and two were improved. Neurosarcoma is a discouraging condition. A given area may be destroyed but recurrence may take place elsewhere along the course of the nerves—not necessarily by continuity. Surgery and radium should be judiciously combined; operation should not be resorted to unless radium can be buried in the tumor if it is found possible. Two cases, one of a cerebral neoplasm successfully treated with radium, and one of an anaplastic glioma with improvement are reported.

L. S. G.

HOUDMONT, H. AND DAUTREBANDE, L. The Radioscopic Examination of the Heart. (*Arch méd. belges*, December, 1920.)

The image obtained by simple radiography is deformed by distance, by the angle of entry of the central ray, and by the pulsations of the heart. It is useless except for verification of position, pericardial lesions, or in examination for aneurysm.

Teleradiography gives a fairly exact image but is rather difficult, requiring powerful installations. Stereoscopic plates of the heart have no value. Orthodiagraphy is the method of choice. Two methods are described. Examination is carried out with the patient in various positions in relation to the screen. Each part of the heart corresponds to a position in which it may be studied with the greatest facility. Examination in the oblique position affords a means of study of parts of the heart inaccessible to ordinary clinical methods.

In functional disorders of the heart, emphasis is laid on the necessity of excluding such conditions as pleural adhesions, encysted pleuisy or large colonic or gastric gas accumulations. A number of charts for comparative measurement are included. The area of each ventricle may be calculated by the reconstruction of the interventricular and the auriculoventricular septa. Emphasis is placed on the importance of the angle of disappearance of the apex behind the vertebral column, and the left ventricle is thus measured. The normal angle of disappearance is 30 degrees. A resumé of the findings in the various organic heart lesions follows. The authors conclude:

(1) *X*-Ray examination of the heart must become a more regular part of the study of the heart.

(2) Radiographs are practically useless; orthodiagraphic calculation offers the only information of any value.

L. S. G.

EDEN, T. WATTS, AND PROVIS, F. LIONEL. A Record of Seventy-six Cases of Uterine Fibroids and Chronic Metritis Treated by the *X*-Rays. (*Lancet*, Feb. 12, 1921.)

The cases presented include 46 cases of uterine fibroids and 30 cases of chronic metritis. About 10 per cent of the cases were less than forty years of age. The cases were selected on the basis of age, size of the tumor, character of the hemorrhages, degree of anemia, and the presence of complications.

They have rarely(8 cases) treated patients less than 38 years old, wishing to conserve the ovarian secretion in patients who were younger. Tumors which exceeded the level of the umbilicus in height were rejected. In cases of irregular and interval bleeding the uterus should be first explored to exclude malignancy. Patients profoundly ex-sanguine were advised to submit to hysterectomy, as the first and second treatments may be followed by increased bleeding. Inflammatory disease, malignancy, and a degenerative tendency in the tumor were considered contra-indications for treatment. The cases for chronic metritis were so labelled for convenience, if no marked enlargement or irregularity in outline of the uterus could be detected.

The authors used from 20 to 30 ma. minutes with a water-cooled tube backing up 8 or 9 inches, and with filtration of 3 mm. of aluminum, and a loofah sponge enclosed in a chamois leather bag with four layers of satrap paper. Six or eight areas on the anterior abdominal wall and four on the posterior wall are irradiated. This dose is not repeated until three weeks have elapsed. The most advantageous time for treatment is shortly after a menstrual period. Nervous symptoms attendant upon the artificial menopause thus produced seemed to be less severe than in the normal menopause.

The authors conclude:

(1) *X*-Ray treatment is the method of choice for uncomplicated cases of severe hemorrhage due to metritis, or other conditions in which neoplasm is not present, and in—

(2) Fibroids not exceeding in size the level of the umbilicus, if the patient is over 38 years old, if the hemorrhage is the regular monthly type and if there are no contra-indications.

(3) All cases should be submitted to a careful gynecological examination before *x*-ray treatment is administered.

(4) The risk of failure with *x*-ray treatment is negligible with properly selected cases.

L. S. G.

EWING, JAMES. The Structure of Nerve Tissue Tumors with Reference to Radium Therapy. (*Proc. N. Y. Neurol. Soc.; J. Nerv. & Ment. Dis.*, February, 1921.)

The structural characters which determine susceptibility to radiation are a cellular character, an undifferentiated form of the cells, rapid growth with an abundance of mitoses, vascularity (especially when due to abundance of delicate capillaries), and the absence of much inter-cellular substance. Neurofibroma might be affected by radium, especially if the radium is applied directly to the tumor. True angio-endotheliomata occur in the rare diffuse sarcoma of the spinal meninges, and should be susceptible to radium. Angiosarcoma should be markedly influenced by radium, since its nutrition is unstable, but whether slow and safe regression can be accomplished, especially with bulky tumors, is doubtful. Glioma presents most of structural features that favor radio-susceptibility. Primary carcinoma of the brain has a structure indicating a high degree of susceptibility to radium. Hypophyseal struma with acromegaly has been definitely influenced by *x*-rays directed through the temporal regions.

L. S. G.

FRANK, LOUIS. Carcinoma in the Cervical Stump after Supravaginal Hysterectomy; and the Radium Treatment of Carcinoma of the Cervix. (*Am. J. Surg.*, Vol. xxxiv, No. 6.)

The coincidental development of cervical and corporeal carcinoma is unusual. The problem of etiologic relationship between carcinoma and fibromyomata remains unsolved, but it is interesting to note that uterine carcinoma occurs in women who have fibromyomata five times as frequently as in those who have no such condition. The development of carcinoma in the cervical stump after supravaginal hysterectomy is rare, less than eighty cases having been recorded in the

world's literature. Radical surgery has produced few cures after the pelvic viscera have become involved in a carcinomatous process. According to Janeway, an elaborate search of the United States discovered only 61 women operated on between 1911 and 1916 who had been cured of cervical carcinoma. The writer cites 38 cases (three of which are reported in detail) of carcinoma of the cervix treated with radium. The three detailed cases received doses of 1200, 2400 and 3600 mg. hours respectively. The dosage at each application was in one case 600 mg. hours and 1200 in each of the two others. Of the thirty-eight cases treated, 18 are well (some of them for two years), 4 show no local evidence of disease but are not well, 11 have died, and 6 cannot be traced.

L. S. G.

Stevenson, Walter C. The Effects of Radium Treatment on War Injuries in the Neighborhood of Nerves. (*Brit. Med. J.*, June 26, 1920.)

The writer reports twelve cases of old nerve injuries markedly improved by radium treatment. He concludes that while radium cannot benefit gross nerve lesions, it does improve the nutrition in the area supplied by injured nerves, and it appears to aid and hasten the return of function in a limb after milder degrees of nerve trauma.

L. S. G.

Ulrici, H. So-called Hilus Tuberculosis. (*Beitr. z. Klin. d. Tuberk.* October 23 1920, xlvi, 1.)

In pulmonary tuberculosis in the adult, the localization of the disease in the bronchial glands which is invariably present has almost always regressed to such a degree as to be seldom demonstrable either by clinical, physical-diagnostic or radiologic resources. As a rule only foci of lime are recognizable as such in the plate. In children conditions are quite otherwise. Here the bronchial glands are of great significance in the genesis of pulmonary tuberculosis. In adults there is practically no pulmonary tuberculosis which has originated in the hilus. The shadow pattern in the plate which has given rise to the contrary impression is due to a confluence cirrhosis of the hilus area, or to a caseous pneumonia which begins centrally—for this latter condition indeed the shadow is pathognomonic. In the adult, pulmonary tuberculosis begins almost invariably in the apex or sub-apex, not only in the side of the hilus originally, but in the opposite side as well. The broadening of the isolated hilus shadow and the reinforced outlines of the lung have nothing to do with pulmonary tuberculosis proper.

Ledoux and Caillods. Sacralization of the Fifth Lumbar Vertebra. (*Presse méd.*, Par., Feb. 13, 1921, xxix, 13.)

In the space of a few months the authors have recognized by radiography no less than 7 cases in which the last lumbar vertebra was incorporated with the sacrum. Nové-Josserand, the well known orthopedist, had called attention to this condition as a cause of various painful manifestations in the lower extremities. He however regards it as very rare while the authors think it may be fairly common, judging from their own experience. The characteristic *x*-ray find is a considerable and symmetrical enlargement of the transverse process of the fifth lumbar vertebra. The shadow of this process suggests the tail of a fish, while when both are considered the resemblance to a butterfly's wings is mentioned. The enlarged process is in contact for a considerable extent with the ilium and upper border of the wing of the sacrum. Compared with the radiograms of Nové-Josserand the condition seen by the authors seems more advanced. Since the last lumbar vertebra is consolidated with the sacrum the enlarged and bifid transverse process suggests an accessory wing of the sacrum superposed on the normal wing. Embryology teaches us that the latter is really the transverse process of the first sacral vertebra. As a result of the malformation the normal lumbo-ilio-sacral interspace through which passes the fifth lumbar nerve is not only much reduced in size but becomes a sort of sacral foramen. While the symptoms do not usually appear in childhood, one of the author's patients was but five years old. The period at which the ossification of the lumbar vertebra to the sacrum occurs has not been determined. The original ossification of the spine

should be complete by the ninth year, while the so-called secondary ossification extends from the ages of fifteen or sixteen to those of twenty-two to twenty-five. This phenomenon has been associated with a disturbance of secondary ossification, but the case of the child of five appears to invalidate this view.

LEHMANN, J. C. Carcinoma Dosage, with Especial Consideration of Carcinoma of the Breast. (*Zentralblatt für Chirurgie.* Leipzig. Vol. xlvii, No. 13, p. 290, March 27, 1920.)

The author points out that to-day practically every surgeon gives patients with carcinoma of the breast prophylactic raying following an operation. He has followed this method for the last seven years and freedom from recurrences for a period of three years has increased. In cachetic patients carcinomas are in no way sensitive to roentgen rays while in senile persons carcinomas are frequently of slow growth and easier to check with roentgen rays.

In chancroid of the lip considerably more than 100 per cent of the erythema dose is required; radium will be usually more efficacious than roentgen rays.

While some progress has been made in the use of the roentgen rays as applied to carcinoma of the breast, the author warns against being over-jubilant lest the method be brought into discredit.

ROBERTS, J. E. H. Oxygen Inflation of the Peritoneal Cavity for Radiographic Purposes. (*Brit. M. J.*, p. 742, Nov. 13, 1920.)

The method of distending the peritoneal cavity by oxygen gas, which was introduced by Weber in Germany, followed by Rautenberg and Goetze in Germany, Stewart and Stein in America, and Alesandrini in Italy has proved to be of great value in exact clinical diagnosis. By allowing the separation of the liver and spleen from the diaphragm, it has enabled the outlines of these organs to be seen for the first time. By compressing and displacing the empty intestines it enables the other solid viscera and abdominal tumors to be examined.

The objections to the method are largely theoretical and no ill consequences have occurred in the fifty cases the author has inflated, nor in any of the many cases of which published records exist.